

*A webcomic of romance, sarcasm,  
math, and language*

**xkcd**

**RANDALL MUNROE**

**2019**

# xkcd

# 2019

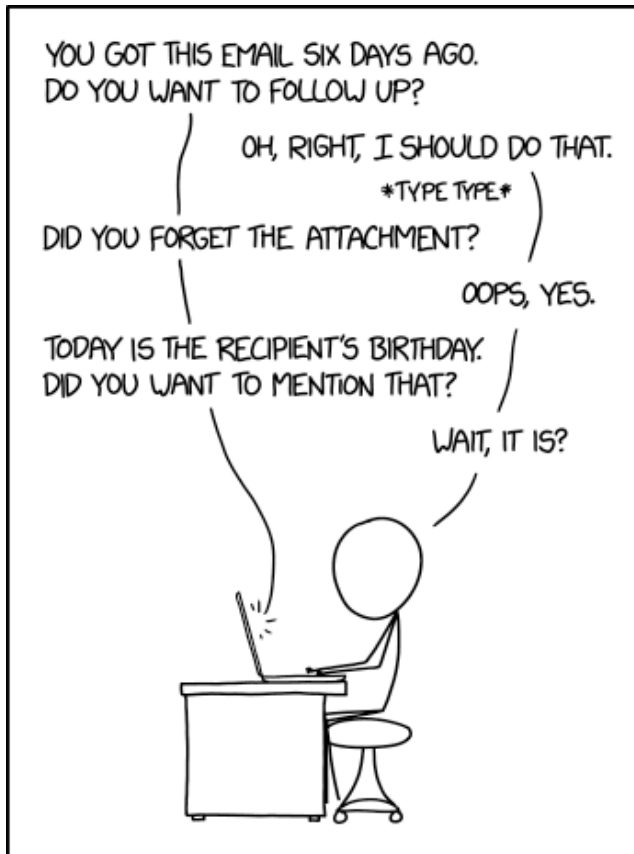
a collection of 156 webcomics

from #2093 to #2248

*by Randall Munroe*

## #2093: Reminders

January 02, 2019



THESE REMINDERS MAKE ME UNCOMFORTABLE, NOT  
BECAUSE COMPUTERS ARE GETTING TOO SMART, BUT  
BECAUSE IT REMINDS ME HOW OFTEN I FALL SHORT  
OF EVEN BASELINE LEVELS OF CONSCIENTIOUSNESS.

The good news is that if the number of work and friend relationships you have exceeds your willingness to do the bare minimum to keep up with everyone's life events and stuff, one way or another that problem eventually solves

itself.



## Explanation

In this comic, Cueball is using an email client program on a laptop, which is a popular tool for communicating by email with others.

In recent years, many email clients have started implementing helpful warnings and reminders to catch common human mistakes and ease the process of communication. One such feature, demonstrated in this comic, is that many clients will now warn you if you've mentioned an attachment in your email but haven't actually attached anything, a common error people make when emailing.

This has gotten to the point where email clients are increasingly stepping in to help with social obligations too; for example, reminding you if you've left an email unanswered for too long, or that someone is celebrating a birthday today and should be congratulated. With the increasing availability of social data and advances in machine learning, these features have the potential to become very sophisticated, to the point that they can effortlessly make social inferences and connections that might have slipped a human user's mind.

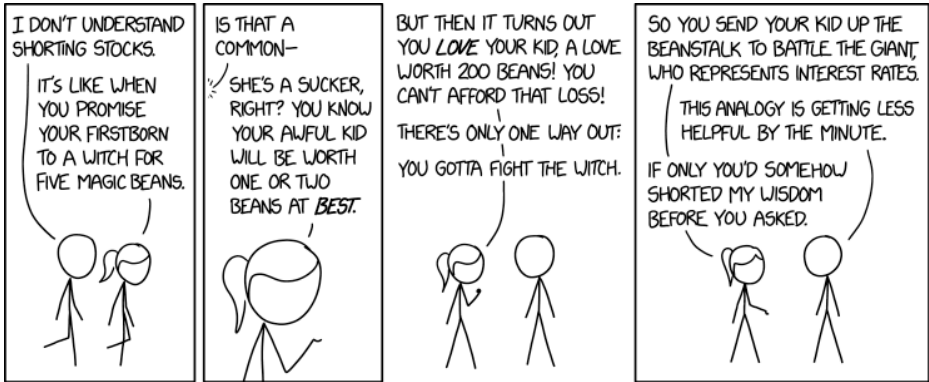
Such features are meant to be helpful aids, but have led people to be worried about privacy issues, or about how "smart" technology is becoming. However, in this comic, Cueball (likely representing Randall himself) has come to the uncomfortable realization that technology is now

easily surpassing his own ability to maintain social relationships with other people, by being more aware of his friends' social lives than he is. He is disturbed by how unwittingly unconscientious he has become.

The title text suggests that the problem of keeping up a baseline level of interest in other people's lives eventually solves itself; implying, somewhat darkly, that if you don't put in even the bare minimum effort to keep up, you'll end up with fewer friends as some get annoyed by your lack of interest in their lives.

## #2094: Short Selling

January 04, 2019



"I'm selling all my analogies at auction tomorrow, and that witch over there will give you **20** beans if you promise on pain of death to win them for her." "What if **SEVERAL** people promised witches they'd win, creating some kind of a ... squeeze? Gosh, you could make a lot of—" "Don't be silly! That probably never happens."

## Explanation

Shorting stocks (short selling stocks) is a stock market practice, generally engaged in by those who expect a particular stock to fall in value. Essentially, rather than buying or selling a stock, one party sells a contract to deliver a stock within a certain period of time, at a price based on the current stock value. If the stock goes down in value, that person can then purchase stock to fulfill the contract at a lower price, thus making a profit. The risk is that, if the value of the stock goes up (possibly by large amounts), the seller then must pay that higher price to fulfill the contract.

Because short-selling is somewhat more convoluted than the simplest form of investing (which is to buy stocks and hope they go up in value), new investors don't always understand how it works. In this strip, Cueball asks Ponytail to explain shorting stocks. Ponytail starts out with a fairy tale story that falls apart almost before she even starts.

The analogy begins with a somewhat common fairy tale trope of a childless person promising their firstborn child to a witch. This is vaguely similar to short-selling, in that a person is receiving payment in exchange for something they don't yet have, but isn't a really helpful comparison, for a number of reasons. Ponytail then posits that the person turns out to love their child, and value them far more than what they were paid. Once again, that's vaguely similar to short-selling a stock, and then having it

go up in value, but is a very bizarre way to demonstrate the notion. In addition to being grotesque, placing a monetary value on your love for your child doesn't reflect how an actual market works (your child is likely worth more to you than to anyone else).

The analogy then goes totally off the rails, telling Cueball that he needs to send his child "up the beanstalk to battle the giant", both of which are completely new elements in the story, and the only justification is that the giant somehow "represents interest rates". Even if that analogy could be justified, it's convoluted and non-intuitive enough that it's not remotely helpful in promoting understanding.

Cueball comments that the analogy is rapidly losing its value to him. Ponytail fires back with the comment that he should have "somehow" shorted her advice before asking for it. This is the essence of short-selling: if something loses value, then someone who shorted it would make a profit. Of course, there is no market for shorting advice, and the value that advice has to Cueball doesn't translate into actual market value. Ponytail seems to be simply mocking Cueball that there's nothing he can do about her advice being useless.

Her story appears to be based on plot elements of multiple fairy tales. It begins by mixing up the story of Rapunzel with Jack and the Beanstalk.

In one version of Rapunzel a Father breaks into a witch's garden to steal the Rapunzel plant for his pregnant wife.

The Witch catches him and agrees to let him go and not punish him in exchange for the child.

In one version of the "Jack and the Beanstalk" fairy tale story, Jack sells a cow for magic beans. His mother, thinking the beans are fake, is angry with Jack. Jack plants the beans and a magic beanstalk grows up into the clouds. Jack climbs the beanstalk and explores the land above the clouds. He finds the home of a cruel giant and proceeds to steal from the giant. The giant discovers the theft and chases Jack back down the beanstalk. Jack reaches the bottom of the beanstalk first and cuts the beanstalk down. The giant falls to his death, and Jack uses his stolen wealth to take care of himself and his mother.

The combination of the two stories is similar to the story from the musical "Into the Woods," in which a Father sneaks into the Witch's garden to steal vegetables, then trades his soon to be born child for the vegetables, but also steals beans in the process.

The title text is actually the most useful part of this comic when it comes to investment advice. It posits a reality in which there actually was a market for advice, and demonstrates how short-selling would work in such a case. The witch (the broker) is offering the father (short seller) 20 magic beans now if the father/short seller buys all of the analogies (stocks) later. If the father believes he can buy the advice for less than 20 beans (because it becomes "less helpful by the minute"), that would seem like a winning trade. But then a risk is brought up: what

if multiple witches/stock brokers make the same deal with multiple fathers/brokers? Since every father/seller now needs to buy the same analogies/stocks, a bidding war erupts and it's impossible to please all the witches. The "winner" pays a much higher price than expected, hence losing money on the deal, and the losers wind up either dead or enslaved (bankrupt). In the stock market the corresponding phenomenon is known as a short squeeze, hence Cueball's comment. Ponytail's replies "that probably never happens", which is almost certainly intended as false reassurance. It certainly does happen in real life, and ignoring such risks is a mark of an unprepared investor.

## #2095: Marsiforming

*January 07, 2019*



It has so many advantages--it preserves Martian life, requires fewer interplanetary launches, and makes it much easier to field-test Mars rovers.



## Explanation

Terraforming is the (so far only suggested) process of changing a planet, usually to make it more habitable for humans or other Earth life. A very common example is Mars, which is known to harbour water ice and believed to have previously been warm enough to have liquid water. Normally, plans for terraforming try to adjust temperatures to be compatible with liquid water, and an atmosphere containing significant amounts of oxygen but little carbon dioxide. The word Terra is the Latin name for Earth, so terraforming would be "Earth Forming".

In this comic Cueball is suggesting doing the opposite: change Earth to be more like Mars, i.e. extremely dry, cold, and with a very thin atmosphere, approximately 1/160 of Earth's surface pressure. In addition, Mars has no magnetic core, so it is possible that Cueball wants to remove the magnetic field from Earth. The comic title combines Mars with Forming (with a linking "i") to create the new word Marsiforming. He is having trouble getting the enthusiastic response to his proposal that he expects.

The title text provides examples of how this could improve things: preserving Martian life (a proposed reason to terraform Mars would be to provide a second planet to preserve Earth life at the cost of destroying any potential [undiscovered] Martian organisms, so by marsiforming Earth, we would provide a second planet

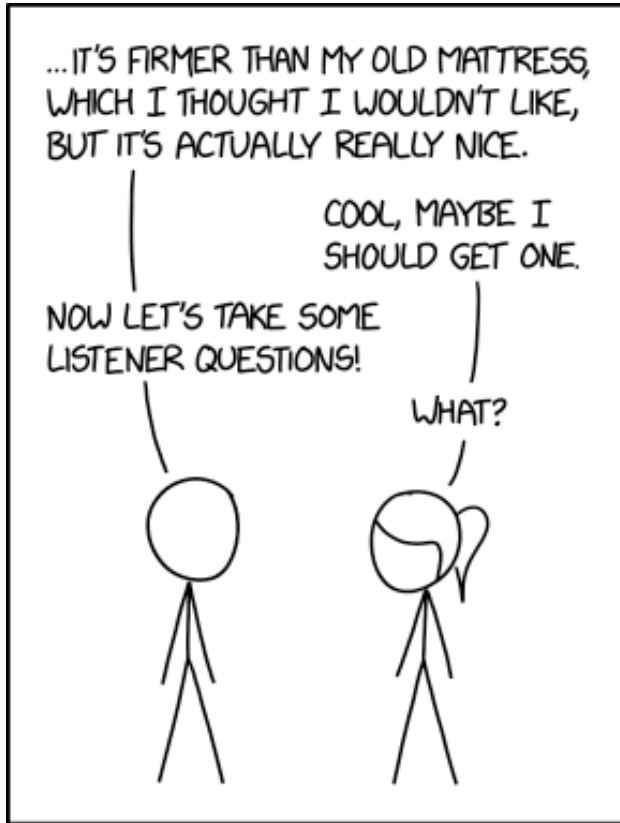
to preserve Martian life, if there is any life on Mars), needing fewer interplanetary launches (no need to leave this planet's atmosphere in order to visit itself, and Martians who might otherwise need to return to their home planet could instead settle on Earth), and making it easier to field-test Mars rovers (field-test means to test in the environment of actual use, which would readily be available on Earth). While the second and third items would indeed be advantages, and the first would be as well if Mars has developed life, they are severely outweighed by the fact that most life on Earth, including humans, would die.

Unstated in the comic are the extreme costs such a proposal would incur, which would surely be grounds for rejection. Between the thin atmosphere, harsh solar radiation, and other changes, Earth would become uninhabitable for most life currently on Earth, most notably humans. Almost all humans value the continued existence of the human race far more than Martian exploration[citation needed] (if nothing else, it is for the benefit of humans that Mars is being explored, so exterminating the human race would render the benefits moot).

There are known extremophile species that would survive underground on Mars. If similar life is hiding on Mars, marsiforming the Earth would benefit their possible eventual interplanetary efforts. There is an existing project to begin experimental terraforming on Mars by nurturing some of our extremophile species on it.

## #2096: Mattresses

January 09, 2019



I CAN'T TALK ABOUT MATTRESSES,  
UNDERWEAR, OR THE POST OFFICE  
ANYMORE WITHOUT FEELING THE URGE  
TO SEGUE BACK INTO A PODCAST.

After reading that "The War To Sell You A Mattress Is An Internet Nightmare" article, I've decided it's safer and less complicated to just sleep on the floor. **DISCLOSURE: THE AUTHOR OF THIS MOUSEOVER TEXT RECEIVED FINANCIAL**

COMPENSATION FROM THE FLOOR INDUSTRY FOR THIS MESSAGE.

## Explanation

Cueball is talking to Ponytail about his mattress, in what appears to be a casual conversation. Cueball suddenly offers to take any questions from listeners, as though the conversation were part of a podcast, which confuses Ponytail. The subtitle explains that Randall has heard so many advertisements for certain products on podcasts that he can't discuss them without feeling as though he's in a podcast himself.

Podcasts are, usually, audio-only programs available online, which frequently generate income through advertisements. Ads are often read by the podcast host. Hosts will often include segues or personal anecdotes to further reduce the "topical whiplash" caused by abruptly switching subjects from that of the podcast to an unrelated brand plug and back.

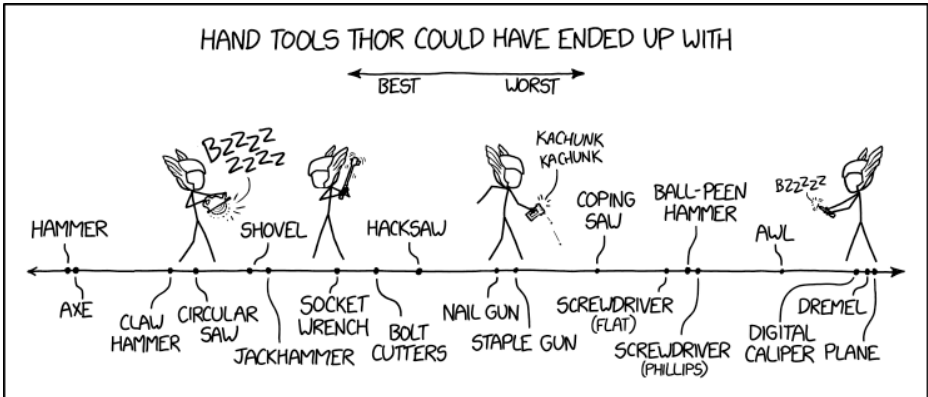
In 2018, many podcasts, or at least many podcasts that Randall listens to, contained ads by Casper or Helix Sleep, both of which are mattress brands, MeUndies or Tommy John, both underwear brands, and Stamps.com, an internet-based mailing/shipping service.

The title text (here named the mouseover text) refers to "The War To Sell You A Mattress Is An Internet Nightmare", which is an article about the pressures companies put on reviewers, the legal battle between a mattress review site that makes money through affiliate sales, and a mattress company unhappy with a review.

Since saying anything unfavorable about mattresses might open one to legal action, the title text author opted to avoid them entirely. However, it turns out this was a sponsored message by the "floor industry", and is meant to increase rates of sleeping on the floor. It also references the way that podcast hosts will often note when they intentionally or unintentionally endorse a product sponsor in an attempt to remain transparent about their financial supporters.

## #2097: Thor Tools

January 11, 2019



**CORRECTION:** After careful evaluation, we have determined that the axis label on this chart was printed backward.

## Explanation

In Norse mythology, Thor is the name of a god of thunder and lightning. His signature weapon is a magic hammer called Mjölnir. In popular culture Thor might be best known for his role in Marvel comics and films, which his appearance here seems to be referencing. In the Marvel Cinematic Universe movie, *Avengers: Infinity War*, Thor also wields an axe named Stormbreaker.

Hammers through history generally served two purposes: as weapons and as tools, though any given hammer is more specialized for one role over the other. Mjölnir is generally interpreted as a weapon, but this comic reimagines it as a tool, then extrapolates that line of thinking by giving Thor other tools instead of a hammer. The comic is listing various hand tools in order of utility and viability as Thor's weapon, besides his actual, enchanted hammer. Hammers are heavy, blunt, and can do large amounts of damage to an opponent, whereas a hand plane is sharp, but only in one place, and will only inflict surface wounds.

Some of these tools require power, which would generally require Thor to stay near an outlet or keep a battery charging, such as the circular saw, or Dremel. However, being the god of lightning may allow him to circumvent this, by producing electricity for the direct current (D.C.) tools, although he would need an inverter to convert the lightning (D.C.) to alternating current



(A.C.) for the tools requiring it. Thor would also need compressed air for the nail gun or jackhammer, only allowing Thor so many shots before reloading the air tank at an outlet, or via a concentrated wind storm.

The nail gun and staple gun would also require nails or staples respectively to function as a weapon. Although Mjölnir is believed to return to Thor if thrown, it's not clear how a similar system could work with nails and staples.

The usefulness of the nail gun as a weapon might depend on whether it was an older one that can be bump-fired or a newer one that requires a separate trigger pull for each nail.

In the title text, Randall writes that the order of the axis label should be reversed, making the plane the best tool and Mjölnir the worst. Considering that the title of the comic is "Thor Tools" ("tools", instead of "weapons"), the argument seems to be that a hammer is less useful than the rest, by seeing them as tools and not as weapons.

A few other interpretations of this could be:

- Randall proposes that Thor armed with a plane or digital calipers would be much more fearsome than with a hammer.
- The "value" of the more strange-seeming items would be much higher than his traditional hammer, perhaps more gory or more humorous.
- Thor tends to cause collateral damage, and would cause

less with a plane or calipers.

- "Best" and "worst" are to be interpreted for Thor's enemies rather than Thor himself.
- Randall might just find the idea of Thor wielding a Plane as a weapon to be really funny.

The title may be a reference to Gary Larson's The Far Side comic, Cow Tools. The comic depicted a cow next to a set of crude tools, and was famous for no one understanding it.

### **List of tools[edit]**

All shown tools are explained below:

## #2098: Magnetic Pole

*January 14, 2019*



I LIKE WHEN THE EARTH'S MAGNETIC FIELD DOES WEIRD STUFF, BECAUSE IT'S A HUGE, COOL, URGENT-SEEMING SCIENCE THING, BUT THERE'S NOTHING I PERSONALLY NEED TO DO ABOUT IT.

People keep trying to come up with reasons that we should worry about the magnetic field collapsing or reversing, but honestly I think it's fine. Whatever minor problems it causes will be made up for by the mid-latitude auroras.

## Explanation

Over the last couple of months, Earth's magnetic fields have been shifting rapidly. Although the magnetic fields do move regularly, the current shift has been unexpected and unprecedented. As many location systems are reliant on the magnetic fields to function, the accuracy of such tools is being shifted beyond the maximum acceptable error. The scientists are therefore updating these tools in order to prevent ships from running aground, similarly to 2029: Disaster Movie.

Locational and navigational systems use the magnetic field, combined with a model of field behavior, to do fancy math and pop out data. Because of the rapid shifts, a new model was scheduled to be created; however, the model has been considerably delayed by the US government shutdown.

As shifts occur, the error of geopositional data will increase until a new model is released. The effect is especially pronounced as you move toward the poles.

Cueball is saying that because of the currently published magnetic declination data being slightly incorrect, his schooners (old merchant sailing ships) may go off-course and crash on [\[\[wikipedia:Shoal\]\]](#)s. This is to illustrate how magnetic pole shift doesn't actually affect many people's daily lives. Modern ships' navigation systems do not rely on magnetic pole location – in contrast to old vessels which mostly used a compass. However, airplanes

do use compasses readings in determining runway numbers. Thus, northern countries have started to use the Geographic North Pole to determine runway numbers, which could otherwise need recalibration on occasion, as would all the (not-necessarily magnetic flightdeck compasses.

Since the movement is only about two-fifths of a degree, it wouldn't cause much disruption for Cueball or require him to adjust anything about his lifestyle, but since the speed of the change has been steadily increasing over the past few years, it may mean we are heading for a geomagnetic reversal in the next few decades, something very exciting indeed. During a magnetic reversal, the poles wouldn't just switch places; several different poles would form and interact chaotically, and it's likely that one of them would end up close enough to where Randall lives to cause auroras to become more common at some point during the transition.

In the title text, Randall mentions that there are reasons people could be concerned, but says that they would be more than made up for by newly being able to experience mid-latitude auroras. Since auroras occur between  $10^\circ$  and  $20^\circ$  from the magnetic poles, the migration of the poles to middle latitudes would cause the auroras to occur there as well; since more people live at middle latitudes than in the Arctic and Antarctic Circles, and since auroras are considered aesthetically attractive,[citation needed] the psychological benefits of the drifting poles might more than make up for the technical difficulties it causes.

## #2099: Missal of Silos

*January 16, 2019*

# MISSAL OF SILOS

FROM WIKIPEDIA, THE FREE ENCYCLOPEDIA

THE **MISSAL** OF SILOS IS THE OLDEST KNOWN **PAPER** DOCUMENT CREATED IN THE CHRISTIAN WEST; IT IS 11<sup>TH</sup> CENTURY IN DATE.<sup>[1]</sup>

THE MISSAL IS HELD IN THE LIBRARY OF THE **MONASTERY OF SANTO DOMINGO DE SILOS** NEAR **BURGOS, SPAIN**. IT IS ONE OF A NUMBER OF LITURGICAL MANUSCRIPTS

SPAIN WOULD LIKE TO REMIND EVERYONE NOT TO USE FUZZY STRING MATCHING IN THEIR NUCLEAR STRIKE TARGET LISTS.

Welcome to Wyoming, motto "We'd like to clarify that Cheyenne Mountain is in Colorado."

## Explanation

This comic plays on the similarity in name between missile silos, places where long range weapons are deployed, and the missal of Silos, an old document residing in Spain.

In Christianity, a missal is a priest's book of instructions, texts, and music for the proper celebration of Mass. The Missal of Silos is an 11th-century missal from the Abbey of Santo Domingo de Silos in northern Spain; it is famous for being the oldest known paper document in Europe, written at a time when the usual writing material was parchment.

Missile silos are often thought to be the first targeting priority in event of a nuclear strike, in hopes of preventing retaliation. If one was searching for potential nuclear missile targets, the Missal of Silos could conceivably be returned as a result of a fuzzy search for "missile silos", and be made a target.

Fuzzy, or approximate, string matching is a technique used for searching text for sequences of characters similar to a given sequence. Normal string matching would only find results that matched the search exactly (searching for "missile" would find only occurrences of "missile"). Fuzzy string matching instead finds results that are "close enough" by some metric (searching for "missile" would find "missile" but also close variants like "missal" or "missel"). Fuzzy string matching is often used in search

engines, as typos, misspellings, and inexact searches are common.

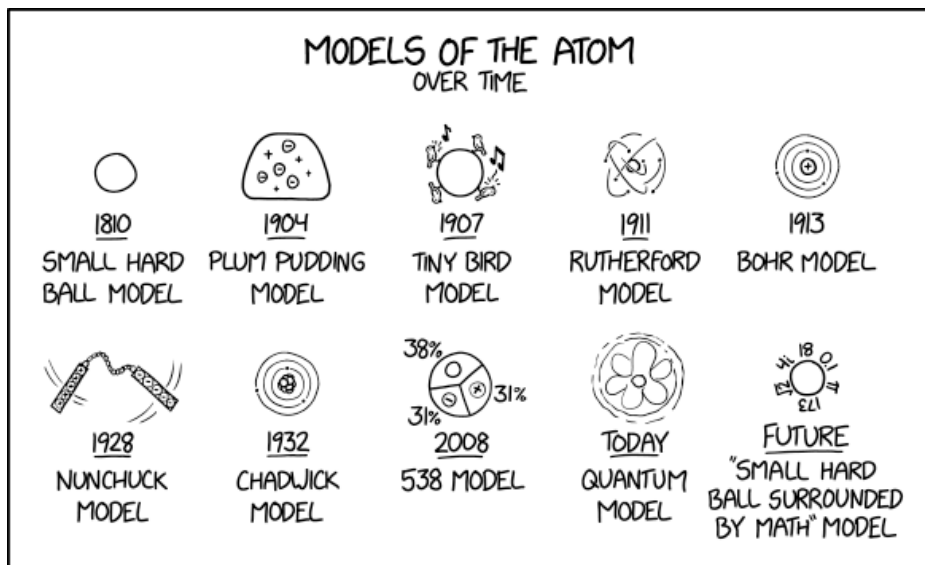
Cheyenne Mountain is a mountain in Colorado, which houses an underground military compound (aptly named the Cheyenne Mountain Complex) designed to withstand a nuclear strike and host to the North American Aerospace Defense Command. Cheyenne, Wyoming, on the other hand, is the capital of Wyoming. The residents of Cheyenne, Wyoming would prefer their town not to be the target of a nuclear attack because of confusion with Cheyenne Mountain.[citation needed] However, Cheyenne, Wyoming is likely a listed target because of the nearby 90th Operations Group at Francis E. Warren Air Force Base operating Minuteman III ICBMs from missile silos.

There have been several comics with nuclear weapons as a part of the plot. See for instance 1655: Doomsday Clock, where several other comics are mentioned in the explanation.



## #2100: Models of the Atom

January 18, 2019



J.J. Thompson won a Nobel Prize for his work in electricity in gases, but was unfairly passed over for his "An atom is plum pudding, and plum pudding is **MADE** of atoms! Duuuuude." theory.

## Explanation

This comic humorously describes the changing view of what an atom is. This has happened so much it seems that we never really knew what we are looking at, and there have been many competing theories aside from the mainstream ones we are taught in school. Randall lists major depictions in the history of our understanding of an atom, and adds a few humorous ones in to poke fun at how diverse, contentious, and in retrospect often foolhardy, this history has been.

The first model shown, in 1810, is said to be a "small hard ball model." Around this time, John Dalton published his textbook *A New System of Chemical Philosophy* which linked existing ideas of atomic theory and chemical reactivity to produce a combined law of multiple proportions which proposed that each chemical element is comprised of a single unique type of atom, and introduced the concept of molecular weight. Dalton's theories form the basis of what is known today as stoichiometry, which underpins chemical reactivity. As atoms were considered at this time to be the smallest possible division of matter the scientific community thought of them as "hard round balls" of different sizes; thus the name described here. The "small hard ball" model is still commonly used when teaching and discussing chemical molecules which do not require the level of detail provided by more advanced models, with atoms represented as small, hard, round balls connected by sticks representing chemical bonds.

In the late 19th and early 20th centuries, the study of these "atom" things faced a crisis: where would the newly discovered "electrons" go? In 1904, physicist J. J. Thomson, who discovered electrons, had an idea: maybe the electrons were small point charges moving around in a big mass of positive charge. This was the "plum pudding model", the second model on the comic, called this because people imagined the positively charged mass as a "plum pudding". (The title text references Thomson as well, along with the humorous observation that plum puddings themselves are made of atoms.) The problem with this approach is that same charges generally repel, resulting in the more mobile or unbalanced charges forming a surface shell around the others, attempting to escape, rather than being content to being randomly distributed among them.

There were many competing ideas in the formative years of what-are-atoms-made-of-ology; Randall makes up a 1907 "tiny bird model," which he suggests might have fit well in the relative chaos of the period. In this model, four birds surround the small hard ball at equal distances to one another. Two of them are singing and the other two are not and all birds are opposite to their identical bird. The non-singing birds balance the singing birds like electrons and protons. This model might be mocking the strange and sometimes illogical models that were presented for the shape of an atom.

The tentative winner in the battle was the model of Thomson's student Ernest Rutherford, who discovered from electrostatic scattering experiments that the positive

charge seemed to be concentrated in the center of the atom, and proposed his Rutherford model, or "planetary model", in 1911, where electrons orbit a very concentrated positive charge. This model has often been compared to the orbit of the planets around the sun, with the electrostatic attraction of the electrons and protons shaping the orbits, rather than gravity. This is the fourth model in the comic.

The Rutherford model could not explain the discrete spectral lines in absorption and emission spectra. It also did not explain why electrons did not spiral in to the nucleus. Niels Bohr patched the model up by proposing that electrons could only exist in distinct "energy levels" at discrete distances from the nucleus. The 1913 "Bohr model", the fifth model shown here, was part of beginning quantum mechanics. Physics behaves differently at the small scale of atoms than the large scales we are more familiar with.

Randall facetiously suggests a "nunchuck model", the sixth model shown, of a packet of protons swinging a packet of electrons around. One can imagine a handle filled with electrons bonded by the strong nuclear force to a chain made of neutrons, bonded again by the strong nuclear force to a handle made of protons. The heavier protonic handle acts loosely as an orbital center as the electron-filled opposite handle swings wildly around it, attempting to resolve its electrostatic attraction within the restraints of its chain.

The next refinement was in the structure of the nucleus.

Note that at this time, nobody thought of splitting up the nucleus into protons and neutrons. But pretty soon people noticed that protons and neutrons existed; James Chadwick, who discovered the neutron, figured that the atom had a nucleus of neutrons and protons, along with a bunch of electrons orbiting around it in a Bohrish manner. This is what the layman today often thinks of as an atom, and is the seventh model shown here.

The eighth model shown is a made up "538 model," in 2008. FiveThirtyEight is a statistical analysis website that gained fame in 2008 for predicting every race but 2 correctly in the US presidential election and predicting every state and Obama's win in the 2012 election. Unlike most other media and polling institutes it saw a rather high probability of 29% for Trump to win the 2016 election by summing up the uncertainties in all the battle states. It has since been known for making mathematical models for everything; the model jokingly suggests that 538 has modeled and presumably made predictions about the atom. The pie chart shows the statistical composition of neutrons, protons and electrons, 38%, 31%, and 31% respectively. This could either be the average of a massive body with several isotopes or represent gallium-69, the most abundant isotope of gallium, with 31 protons, 31 electrons and 38 neutrons. FiveThirtyEight has previously been mentioned in several xkcd comics, including in 477: Typewriter, 500: Election, 635: Locke and Demosthenes, 1130: Poll Watching, 1779: 2017, and 2002: LeBron James and Stephen Curry. It's appropriate to list the 538 model as a

precursor to the quantum model, as it is a step towards considering the likelihood of different quantities of subatomic particles to be in different volumes of space, rather than considering them as strictly kinematic particles. The comic moves this development into 2008 in support of this joke, when it was actually made much earlier.

But the Chadwick model is not what scientists endorse today.

The theory of electromagnetism says that accelerated charges, like the electrons circling, would lose energy emitted as electromagnetic waves and would quickly orbit into the nucleus. Bohr only postulated that this would not happen, but his model could not explain why. Another problem[citation needed] is that atoms, even the hydrogen atom, are not flat - which they would be, if a single electron orbited in a circular or elliptical trajectory (the circular motion of charge results in a magnetic moment; Otto Stern and Walter Gerlach showed that independent from the direction of the measurement the angular momentum - for certain elements - always has the maximum positive or negative value, i.e. not only the radius, but also the angular momentum is quantized - and never zero. You cannot 'look at' the atom from above and 'see' the orbital circle. It always 'seems', as if you 'looked' from the side and would measure the full magnetic dipole. Stern and Gerlach actually saw the spin of an electron of the silver atom instead of the angular momentum, which is according to quantum mechanics 0).

Today (i.e. actually since 1926, 29 years after the discovery of the electron) physicists subscribe to a quantum model, which is the ninth model shown here. Instead of electrons with definite location and momentum ( $\sim$ speed), the parts of the atom are described by probability fields of possible locations and momentums. The changes in momentum probability normally cancel each other out, so there is no electromagnetic radiation.

Although the "quantum model" of today is already very abstract, the next model is postulated to get so abstract that it is just a "small hard ball surrounded by math". The last model shown is thus remarkably similar to the model we started out from, the "small hard ball model" (without the math).

The picture for the "small ball surrounded by math" depicts a circle with several numbers around it. While the numbers seem to symbolize the "surrounding math" in a general sense, some of them suggest constants used in actual mathematical equations or other numbers related to the quantum model. The shapes and densities of the atomic orbitals are calculated with the Schrödinger equation, which is complex and difficult to solve. For this reason atoms are generally precisely considered in only very simple simulations, and the details of interactions of many atoms at large scales that form our daily lives are incredibly hard to precisely understand and predict on an atomic level. It comes down to "these roundish things we call atoms are moving around in these approximate ways obeying this complex equation

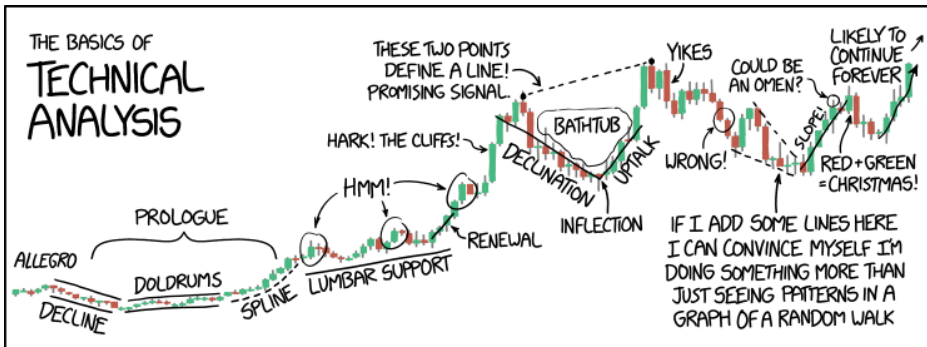
with too many numbers involved in most situations to accurately model, so let's use a different, empirically derived formula that describes the behavior of the system in general."

This model is probably a reference to the mathematical universe hypothesis and, as a striking case of prescience, may be seen as a prediction of April 2020's Wolfram Physics Project.



## #2101: Technical Analysis

January 21, 2019



"I [suspect] that we are throwing more and more of our resources, including the cream of our youth, into financial activities remote from the production of goods and services, into activities that generate high private rewards disproportionate to their social productivity. I suspect that the immense power of the computer is being harnessed to this 'paper economy', not to do the same transactions more economically but to balloon the quantity and variety of financial exchanges." --James Tobin, July 1984

## Explanation

There are two recognized methods to attempt to predict the stock market, each with its own pros and cons:

- Technical analysis is more appropriate for traders seeking to benefit off short-term fluctuations in stock prices, by attempting to look for trends, momentum, patterns etc. in the stock prices.
- Fundamental analysis is more appropriate for investors seeking to benefit off long-term fluctuations in stock prices, by attempting to guess future earnings based on some fundamental factor about the companies whose stock is traded. Investors can choose to look for good Price/Earnings ratio, the potential of a company to disrupt markets or open new markets, or other indications that a stock may be a solid investment.

Random Walk theory suggests that neither of these methods are particularly useful at predicting the future of the stock market.

The theoretical value of a stock is its net present value, which is the sum of all its future earnings, with earnings in the future discounted appropriately to account for the time value of money. Because these earnings are never fully predictable, traders may have different ideas about the true value of a stock, and buy the stock if they believe the currently offered prices are particularly low, or sell it when the prices are high.

Technical analysis, however, does not even attempt to understand the earnings of the stock, instead focusing on the shapes and patterns that result from traders making their moves. While there is a human behavioral component to stock trading, it is not clear that one can extract much information from the shapes of stock charts. To the extent it does work, a substantial part of its success may be simply an artifact of the herd behavior of traders who engage in technical analysis, a zero-sum game.

The comic displays a stock price chart, annotated with labels which purport to be technical analysis. These labels are nonsense from the perspective of technical analysis, but do accurately describe the graph itself: "allegro" (a musical term used to set the tempo at the beginning of a score), "prologue" (an introductory section of a play, book, or similar), "lumbar support" (the thing in a chair shaped to better support your back), "bathtub" (possibly a reference to the so-called "Bathtub curve"), "uptalk" (a speech pattern). One label celebrates that "these two points define a line! Promising signal." (In geometry, any two points define a line.)

The shape of the chart is similar to the exponential behavior of cryptocurrencies when they are successful, where price (positional height on the chart) roughly increases while volatility (height of the bars or candles themselves, and of the peaks and troughs, on the chart) does the same. Technical analysis used to be an esoteric domain held by well-paid stock analysts, but as cryptocurrency has spread, and as financial companies

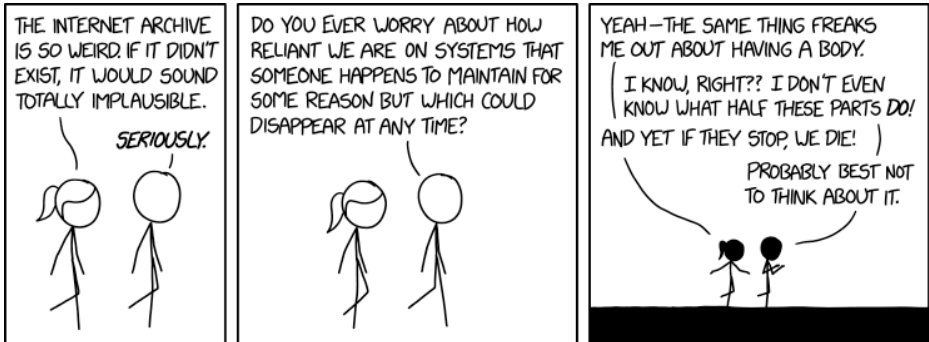
have made it easier for members of the public ("retail investors", as opposed to "institutional investors") to engage in investment trading, people from all walks of life have begun staring at charts like this.

The title text is a quote from James Tobin (from his 1984 paper On the efficiency of the financial system) that raises a question of very talented people building systems to make themselves a lot of money without actually accomplishing anything worth money. The quote was about the stock market and high speed traders in particular. It comments on the 'financialization' of the economy, where activities like speculation and abstracted financial products have become an increasingly large part of the economy, as opposed to investment in productive industry.

Interestingly, this comic appeared the day after Oxfam reported that the world's 2,200 billionaires had added 12% to their wealth in 2018, while the 3.8 billion people comprising the poorest half of the world's population had lost 11%. Perhaps this prompted what appears to be Randall's jab at those whose business is merely making money.

## #2102: Internet Archive

January 23, 2019



The fact that things like the npm left-pad incident are so rare is oddly reassuring.

## Explanation

The Internet Archive is a project that is invaluable for internet research. It is a public archive of information, including public domain books and music. It also runs the Wayback Machine, an archive of backups of web pages all over the Web at various times that can be used to see past versions of a page, even if that site has since shut down. The Internet Archive accepts submissions of any type of information, including new backups of web pages and newly-made public domain content.

Ponytail and Cueball first remark upon how weird the concept of the Internet Archive is, commenting that it would seem like an implausible concept if not for the fact that it already existed.

This revisits a point that Randall made in 2085: arXiv: in the title text for that comic, he wrote,

Our culture has an overarching theme of equating profit with success, so when efforts succeed due to inherent public benefit, this can often yield surprise.

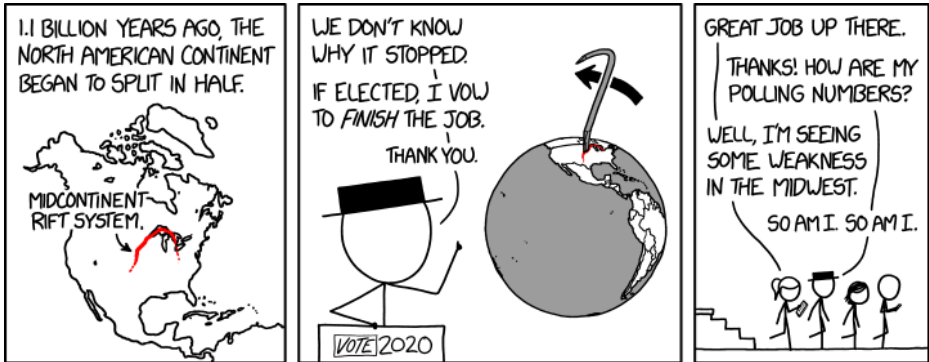
They then become more philosophical, and wonder about invaluable systems that are maintained by a just a few individuals, meaning that they could disappear if any of those people stopped doing what they were doing. They relate this to the function of the human body, which does contain many systems whose function and inner workings are unknown to the average person.

Again, as in 2085: arXiv, the two try not to "jinx things" by drawing attention to the improbability of this system working perfectly. In arXiv, when Megan exclaims that being able to post research papers as free PDFs on arXiv "makes no sense at all", Ponytail responds, "Shhh, you'll jinx it!" Here, Cueball tells Ponytail, "Probably best not to think about it." This is ironic as the inclusion of this information in a popular comic like xkcd is drawing attention to it.

As an example of "invaluable systems maintained by just a few individuals", the title text refers to the "npm left-pad incident", a 2016 incident where a package for the npm package manager was removed from the software library by its author. As this particular package was used by many projects, both directly and indirectly, this caused a severe disruption in the software world. Randall is relieved that cases like this do not occur more frequently. This topic appears to stay on his mind for a while, since 2347: Dependency covers a similar theme.

## #2103: Midcontinent Rift System

January 25, 2019



The best wedge issue is an actual wedge.



## Explanation

Recently, USA politics has caused polarization of the public. It is said to be “split” in two camps (progressive/liberal, mostly loyal to the Democratic Party, and conservative, mostly loyal to the Republican Party). Here Black Hat is trying to get elected to some sort of federal office in the at the time upcoming 2020 elections by promising he will actually split America in two. His presentation illustrates, using a giant crowbar, the completion of the Midcontinent Rift, which is a large crack that started to form about 1.1 billion years ago, but failed to completely sever the continent. Around the same time, the rift was also mentioned in "How To", Chapter 9: How to build a lava moat.

It is unclear why anyone would vote for such a thing, but people directly affected (the Midwest) are likely to vote against Black Hat. While Black Hat and his campaign advisor Ponytail speak of weakness in the Midwest, they are talking about two different things: Black Hat refers to the physical weakness of the North American Plate in the Midwest due to the geological rift which he thinks could be exploited by a large enough crowbar, while Ponytail is referring to a political weakness for Black Hat's campaign in the Midwest due to the likely-unpopular proposal (different regions of the US have different voters and populations who have different priorities and stances, so candidates and their campaigns' platforms will likely be more popular in some regions and less popular in others). In this case a successful or attempted completion of the

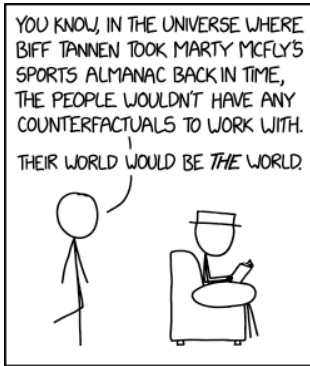
rift would likely result in the destruction of millions of houses, buildings, and other man-made structures, not to mention the deaths of many humans (if proper evacuation were not fully implemented and enforced) as well as millions of animals that could not be evacuated. The proposal would also cause huge economic impacts; the Midwest produces a significant proportion of America's food supplies and hosts important economic centres, such as Chicago and Cleveland. So the popularity among those directly or even indirectly affected is likely quite low. The successful passing of a highly destructive measure such as this would generally involve more direct and overwhelming compensation of the many interests that would otherwise be harmed, to incentivize them to vote against their present livelihood.

The title text is a pun. A wedge issue is a controversial issue which splits apart a demographic group. It is often introduced to create controversy within an opponent's base so that if the opponent takes any position on the issue, half the voters will desert the opponent. Here the joke is that the "wedge issue" is an actual wedge to split apart the United States. It could potentially be a wedge issue, as while most people would oppose such a measure, some people could be convinced that it would benefit certain Midwestern cities by making them port cities, which would result in an economic boom and make trade easier if those cities weren't destroyed. Also, some die-hard liberals living outside the Midwest might favor the destruction of the Midwest because it tends to vote conservative (with a few exceptions, such as Illinois

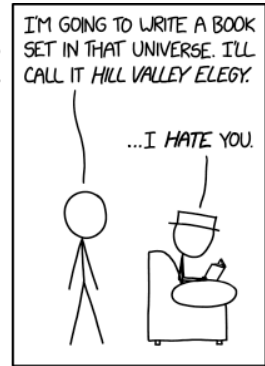
and Minnesota, which are more reliably progressive in their voting patterns). Ponytail seems to state that Black Hat's proposal is only unpopular in the Midwest.

## #2104: Biff Tannen

January 28, 2019



THEY WOULD HAVE SPENT DECADES DEBATING WHICH STRUCTURAL PROBLEMS ENABLED THE RISE OF BIFFCO, THE DECLINE OF THE CITY, AND GENERAL SOCIAL DECAY. EVERYONE WOULD FIND REASONS IT CONFIRMED THEIR PET THEORY.



I can't help myself; now I want to read a bunch of thinkpieces from newspapers in Biff's 1985 arguing over whether the growth of the region into a corporate dystopia was inevitable.

## Explanation

Cueball is expounding a theory to White Hat regarding the alternate timeline seen in the movie *Back to the Future II*, in which the character Biff Tannen stole a time machine and used it to travel 60 years into the past to 1955. In that timeline, Future Biff gave his younger self a sports almanac containing 50 years of outcomes of sporting events, which enabled his younger self to earn millions from betting on horse races and other sporting events. The result is that the altered present of 1985 has become a corporate dystopia due to the actions of the exceedingly wealthy Biff and his company, BiffCo.

Cueball's theory is that the people now living in this dystopian 1985 would never know that their timeline was altered; as far as they are concerned, theirs is the true timeline. Because of this, they would seek to analyze every detail of Biff Tannen's rise to power, inventing their own theories as to his success and arguing with each other over the supporting evidence.

However, in the third panel, it becomes clear that this has all merely been Cueball's elaborate setup for a bad pun, causing White Hat to voice his disapproval.

This comic is based on *Back to the Future II*. In this movie, the character Biff Tannen steals the time machine, which is the main plot device, and uses it to go back in time from 2015 to 1955. He then gives Marty McFly's sports almanac, containing the outcomes of 50

years (1950–2000) worth of sporting events, to his own younger self. His younger self uses this sports almanac to make millions by successfully betting on horse races. He then forms a company, and calls it BiffCo. In the movie, the protagonists reverse this, by going back to 1955 and stealing the almanac back soon after Biff delivered it. It is heavily implied that this universe, also called “1985A” in the movie, stops existing after this change.

The movie is set in the fictional town of Hill Valley, California. When the protagonists return to 1985, they find that Biff has turned the town’s “Courthouse Square” into a 27-story casino, and generally taken over Hill Valley. This has apparently resulted in the town being overrun by armed gangs, and beset by crime, violence, corruption, and an overall atmosphere of quasi-dystopian misery. This is what Cueball refers to as “the decline of the city, and general social decay”.

Further, a newspaper headline seen in that universe reads “Nixon to Seek Fifth Term; Vows to End Vietnam War by 1985”. Nixon was a notoriously corrupt President of the United States who was involved in a burglary of his political opponents’ campaign headquarters (either through directly ordering it or in covering it up), and implicated in various related illegal and unethical activities. He resigned in 1974 after he came to believe he would be convicted by the Senate and removed from office after he was impeached by the House.

The Vietnam War was a proxy war between the USA and USSR and their respective blocs, characterized by

American efforts to eliminate communist-backed insurgents. In reality, real and perceived failures to make progress, and growing domestic opposition to the human and financial costs of the war, led to the withdrawal of all American armed forces by 1973.

This headline in the alternate timeline implies that Richard Nixon remained President until at least 1981. In reality, this would violate the 22nd Amendment, which limits Presidents to two four-year terms in office; hence, the headline implies that this amendment has been repealed or is being ignored. All of this suggests that the United States government has become much more authoritarian and corrupt in that universe. Further, the continuing Vietnam War would have resulted in millions more deaths and billions more dollars of additional direct and indirect losses than were caused in reality.

Cueball mentions that this universe – that is, the 1985A Back to the Future timeline – would not have any counterfactuals to work with. This is often short, in epistemology, for counterfactual conditionals, that is, conditional statements about what would be true if something were true that we know for a fact is not true. Randall's what if? series is based on counterfactuals, since it explores hypotheticals — conditionals which are contrary to fact. For example, the first “what if?” post, about what would happen if you tried to hit a baseball that was thrown at 90% the speed of light, is a counterfactual, because we know for a fact that a baseball has never been thrown at such a speed[citation needed]. In the case of the 1985A universe, they would not have

any information on the counterfactuals, that is, the facts about what would happen if Biff did not have this almanac.

Hillbilly Elegy: A Memoir of a Family and Culture in Crisis is a book, published in June 2016, that gives an account of growing up in a poor Rust Belt town, and gives a broader, probing look at the struggles of America's white working class. This comic is a play on the title of this book, which has been described as explaining the "social, regional, and class" issues in white working-class America. The white American working class was a key factor in the election of U.S. President Donald Trump, and many critics have interpreted the book as an explanation of his election, which was deemed improbable by many analysts before it happened. Netflix had purchased the rights to an upcoming film adaptation of the book three days before this comic, prompting another wave of criticism of the book's theories.

Cueball is proposing a similarly-titled book, set in the Back to the Future II 1985A timeline, that would describe the supposed factors leading to the rise of Biff Tannen in Hill Valley. In that universe, while the rise of Biff — and the subsequent decay of the city and other issues discussed above — is the result of his using a future sports almanac to cheat at sports betting, the rest of the population would have to guess at the structural societal issues that might have caused these otherwise inexplicable trends. Thus, Cueball compares such blind guessing with the analysis contained in Hillbilly Elegy.



This makes White Hat angry. This may be for various reasons:

- Because it's such a painfully long setup for a really stupid pun.
- There is a decent chance that the book White Hat is currently reading is Hillbilly Elegy. If he is enjoying it, this would make the joke more insulting to him, as it compares the book to useless theorizing about an event which was really caused by time traveling.
- After seeing the similarity alluded to by Cueball between our current reality and a reality where the book Hill Valley Elegy is written, he might imagine that we may be living in a world in which Trump's election was predetermined, just as Biff's rise to power was predetermined by time travel. If he opposes Donald Trump politically, it would probably frustrate him to imagine that being optimistic for the future would be in vain, as any social change he might hope for may be simply predetermined not to happen, perhaps by time travelers.

Randall is known to have supported Hillary Clinton, the main opponent of Donald Trump, in the 2016 U.S. presidential election, having made a comic just to promote her. This may add to explaining the comic in the following ways:

- Randall may have made this comic to disparage a book which supposedly explains the election of the candidate he opposed, by comparing it to useless (and wrong)

theorizing.

- The comic may be intended as an insult to Trump himself, by comparing the dystopian 1985A universe, where Biff rose to power (albeit not as President) to the actual universe, where Trump was elected to the presidency.
- The comic may be an allusion to alleged Russian tampering of the 2016 U.S. elections: Randall may be proposing that it is futile to attribute Donald Trump's rise to power to any set of structural societal issues that may have acted indirectly, while ignoring the hidden, speculated, but far more direct cause of foul play, just as it would be futile to analyze Biff Tannen's rise to power by similar means, ignoring the impact of foul play via time travel and a sports almanac.

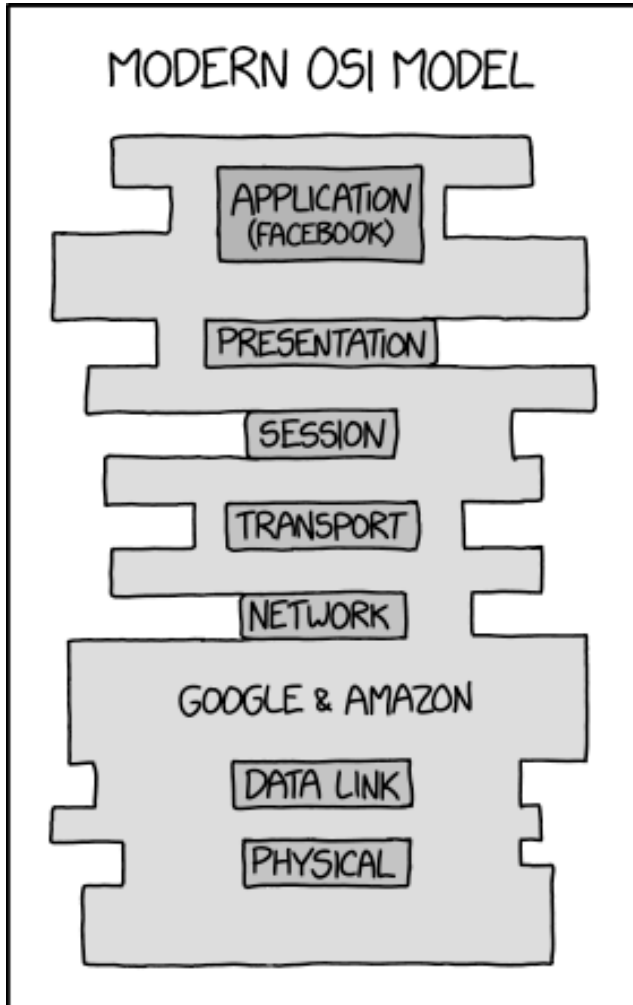
The title text continues the comparison to the election situation by mentioning thinkpieces from newspapers that would appear in the Back to the Future II 1985A universe in which Biff has taken over. Various thinkpieces did appear in real life newspapers in an attempt to explain Trump's rise to power after his election, and asking whether it was inevitable.

As Back to the Future II's important October 2015 setting date approached, commentators began noting the similarities between the older version of the character Biff Tannen and then presidential candidate Donald Trump. When the comparison was brought to the attention of the film's writer, Bob Gale, in an interview, he claimed that elements of Tannen's personality were

actually based on Trump, who was already well known in the late 1980s for his work in real estate and tabloid controversies. Thus, there is a real connection between Biff Tannen and Donald Trump. This supports the comparison between the two made by Randall. That being said, actor Tom Wilson has denied that his performance of the role was in any way based on Trump.

## #2105: Modern OSI Model

*January 30, 2019*



In retrospect, I shouldn't have used each layer of the OSI model as one of my horcruxes.

## Explanation

The Open Systems Interconnection (OSI) Model is a conceptual model for network communications that defines 7 layers of functionality, where higher layers add increasing complexity to lower layers through associated protocols and standards. The 7 layers in the standard OSI Model are:

- 7. Application layer: Defines how applications interact with the stack to request and receive information
- 6. Presentation layer: Defines how one or more sessions are used by endpoints to send and receive a packet of information
- 5. Session layer: Defines how communication events are initiated and managed in order to successfully transmit information
- 4. Transport layer: Defines how information is transmitted across the nodes of a network
- 3. Network layer: Defines how nodes are interconnected to form a network of nodes
- 2. Data link layer: Defines how data is transmitted across a wired connection
- 1. Physical layer: Defines the wiring connections between two different nodes

In practice, the OSI model abstracts the communication between two end points, like a Facebook client and Facebook servers all the way from the application layer

on the server, down to the wire on which the data is transmitted, and back up to the application layer where the user views the data. As Facebook is one of the most used websites in the world with more than a billion users, Randall claims that the "application" layer (what the client sees and uses) is mostly Facebook.

A light gray shape labeled "Google & Amazon" surrounds all seven layers of the model in an irregular shape indicating that Google and Amazon, by dint of their size and dominance at multiple layers of the model influence the entire structure. An example of Google's influence would be their introduction of new protocols like QUIC and SPDY as replacements for the existing TCP protocol that was a foundation of the web, and their accompanying modifications of the original HTTP protocol.

The significance of the irregular pattern of the "Google & Amazon" blob isn't clear. It is likely that it is in reference to the irregular way in which their modifications to the OSI stack have evolved. Potentially with extensions to the left representing the influence of Google, and extension to the right representing the influence of Amazon. However, it is also notable that the irregular structure of the stack is reminiscent of a Jenga tower. Jenga is a game in which blocks are removed from a vertical stack and added back to the top until the whole collapses. This may be a commentary on the instability of the network stack in general, or on how Google and Amazon's additions and changes to it have destabilized the networking protocols. Or, the specific blocks to be

pulled out (presentation, session, and network) may be the ones whose removal collapses the tower while the other ones can be easily removed and replaced (like the center blocks in Jenga), implying that between Google and Amazon, even if these were pulled out, the tower would remain standing. What this says about the three layers that would destabilize the tower is unclear.

Another interpretation: Google and Amazon's market dominance is so extreme that (according to Randall) most users only access layers 1 (Physical), 2 (Data Link), and 4 (Transport) through Google and Amazon. Layers 3 (Network), 5 (Session), and 6 (Presentation), while strongly influenced by Google and Amazon, have at least not been completely swallowed up by those two companies.

The title text refers to Horcruxes used by Voldemort in the Harry Potter book series. A Horcrux is a magical artifact used to house a wizard's soul, preventing them from dying if their body is destroyed. Since they can only be created by murdering other people, they are heavily forbidden, and before Voldemort it was unheard of for a wizard to use more than one. Voldemort used seven -- the same number of layers in the OSI model. However, while Voldemort hid his seven Horcruxes in different places to make himself that much harder to kill, Randall's have all been collected in Google and Amazon, defeating the purpose of using more than one. Alternatively, transforming each layer of the OSI model into a horcrux may be regarded as a strategy to prevent them from being destroyed since doing so would destroy networking. This

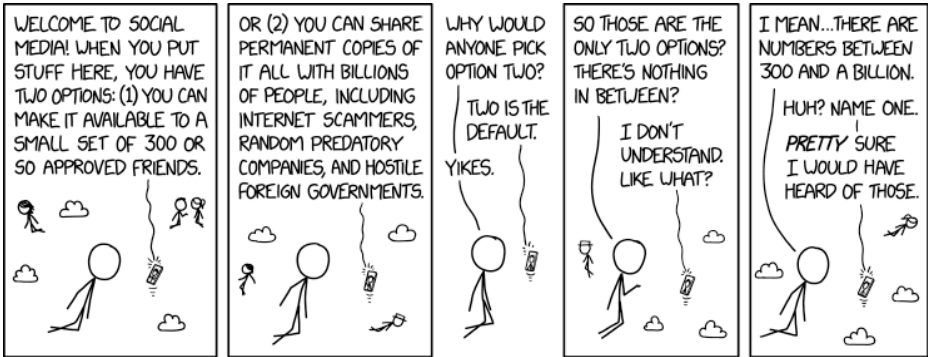
strategy would fail in the modern world, since some of the envisioned layers were not used in the more common modern TCP/IP networking model and in the case of cloud infrastructure potential exists to provide even more shortcuts.

The title text may also be a reference to a prior comic about Randall mixing up things that come in groups of seven, like data layers and Horcruxes.



## #2106: Sharing Options

February 01, 2019



How about posts that are public, but every time a company accesses a bunch of them, the API makes their CEO's account click 'like' on one of them at random so you get a notification.

## Explanation

Cueball is signing up for social media, represented in the comic as a Virtual Reality cyberspace where humans float through the sky with clouds and talk to a virtual assistant shaped like a talking smartphone device. Ponytail and other characters can be seen in the background.

The virtual assistant is explaining Cueball's options for sharing information on social media: he can make it available only to those he selects — what most sites call a "Friends Only" option — or he can make it available to everyone — what most sites call a "Public" post — which by nature will unfortunately include various high risk groups.

Many social media sites allow users to control who can see content (posts, pictures, etc.) that users share. Several high profile social media sites have sparked controversy by automatically widely sharing user data, unless the user restricts access. The settings for controlling the sharing of data are not always obvious to the user, or easy to use. Access may be limited to immediate friends, or be available to all users (public); some platforms allow intermediate levels of control.

As most social media sites are free to use, the business model for these companies involves a mixture of selling advertising space on their website and selling data on its users. Targeted advertising takes data on users' past behavior and things that they have liked, and uses this to predict what adverts they may be interested in or be most

vulnerable to. Targeted adverts are more valuable to advertisers as they avoid paying to show adverts to individuals who are unlikely to be interested in their products; but can lead to users feeling that they are being spied on. While the terms and conditions for social media websites will include details of how data will be used, the length of these documents and legal terminology may deter users from reading them, meaning that they may be unaware that their data is being exploited in this way. Regulation has been slow to catch up with changing online trends; however, the European Union have recently introduced General Data Protection Regulations (GDPR) which aims to regulate how user data can be shared. GDPR was featured in comic 1998: GDPR.

Data from social media may be used for marketing, for law enforcement, mass surveillance and social control, for investigative journalism, for criminal activity, confidence games, among other things.

Internet scammers use online information to manipulate people, often to commit fraud. They may acquire personal data using web crawlers to automatically scan social networks for personal information (particularly emails) to scam their owners. Those bots called web crawlers can get the information without scammers' manual browsing of the victims' profile. Those people who set their social network account as public (the 2nd option in the comic) are more likely victims of scammers since they can access their profiles without being the victim's friend or follower.

Other examples of questionable uses for social media on xkcd include 300: Facebook.

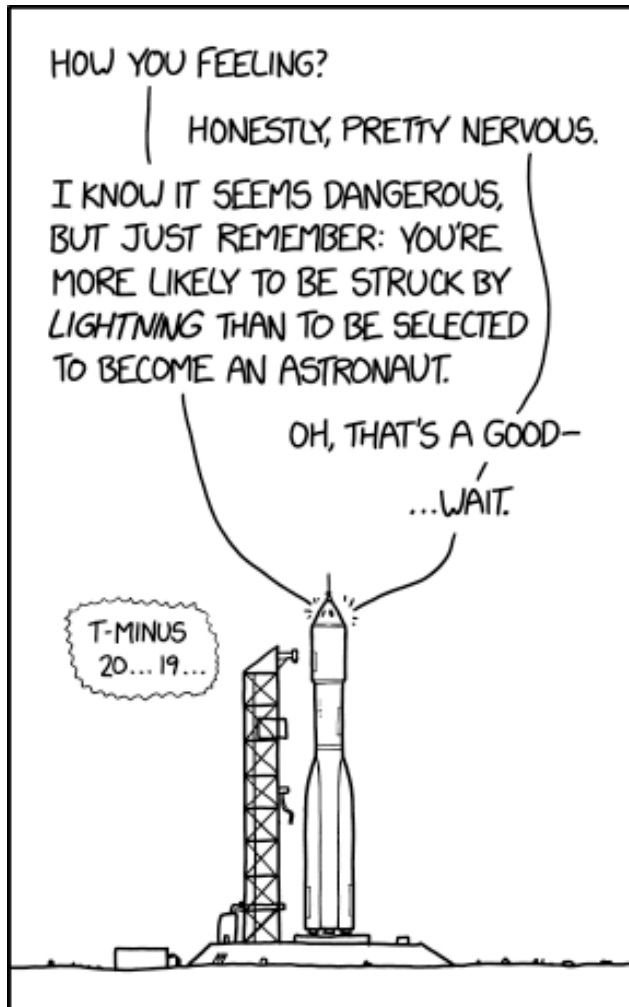
Randall is making a point that there ought to be some option between sharing posts only with your friends and making them completely public. The title text shows that he would specifically like to know when corporations read regular peoples' posts.

This also could be a stab at the sharing policies between Facebook and the just-announced end of Google+. Google+ allowed users to create multiple groups called 'circles'. Posts could then be shared by targeting specific circles. For example: "I'm in the hospital" could be shared with just the family circle, but the "I got a promotion" could be shared with the family circle, the co-workers circle, and the general public circle. Facebook provides an option to share with "friends of friends," leaving the decision about how widely a post is shared not with the posts creator, but with the posts recipients.

The comic is set in the future of VR, yet the fact that Internet companies like Facebook, Tencent and Twitter try hard to collect and sell user data won't change. This may suggests that Randall believe those companies will never reconsider their approach regarding user privacy.

## #2107: Launch Risk

February 04, 2019



Don't worry--you're less likely to die from a space launch than from a shark attack. The survival rate is pretty high for both!

## Explanation

This comic deals with the faulty application of general statistics based on a large population, such as all Americans, to specific situations with vastly different statistics, such as astronauts.

A manned rocket ship is about to be launched into space. Mission control counts down from "T-minus 20," where "T" stands for the time at which the rocket is scheduled to launch. In the capsule, one astronaut asks another how they are feeling. The second admits that they are nervous. The first one offers a supposedly reassuring observation that they are more likely to be struck by lightning than to be selected to become an astronaut. Such comparisons are commonly used to illustrate that a particular probability is very small, and therefore not worth worrying about.

The second astronaut is about to agree that they have a good point, but then realizes the problem with their argument: the likelihood of being selected as an astronaut is a moot point, because they both already are astronauts. The comparison ignores the relevant concern, which is the danger involved in being an astronaut and launching into space. It may also provoke a false understanding that, given two events each with given likelihoods of happening, where chance has proven sufficiently provident enough for the less likely one to have occurred, the 'luck threshold' has been exceeded enough to make the more likely one now a practical certainty (a variation

upon the hot hand fallacy, though with nominally independent events and opposing desirabilities).

The second astronaut's nervousness is understandable as space missions are historically quite dangerous, and have numerous avenues for potentially fatal failure, certainly far beyond the minuscule risk of being struck by lightning, approximately 1 in 14,600 throughout your entire life.

The title text creates additional confusion by referencing another common statistical reference point, the probability of dying in a shark attack. In addition to shark attacks being uncommon, they are also less likely to kill their victim than is commonly assumed. Still, while shark attacks are more frequently fatal than rocket launches, this comparison is once again useless, as the astronaut is not in any danger of sharks, but is literal seconds from launching into space. The astronaut is presumably not especially reassured by the "pretty high" survival rate.

Of the 557 people who who had been in Earth orbit (as of the time of this comic) 18 (3%) have died in related accidents, not specifically at launch (List of spaceflight-related accidents and incidents, Astronaut/Cosmonaut Statistics). Of the 93 incidents logged for 2018 in the Global Shark Attack File, 4 (4.3%) were fatal, but the statistic has been higher in the past when there was likely less education against provoking sharks.

A large metal rocket, such as depicted would be more likely to be struck by lightning than nearby structures. However launch controllers generally monitor weather carefully to reduce the chances of attempting to launch when lightning is likely.

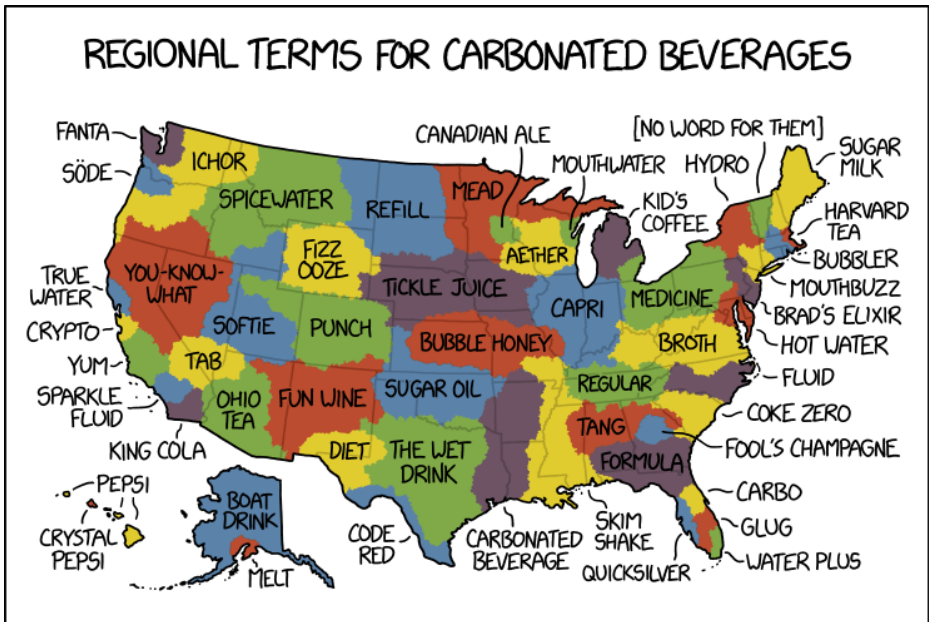
A spacecraft launch can also trigger lightning, by creating a conductive path through electrically charged clouds. Apollo 12 was struck by lightning twice during the launch phase. Thankfully backup systems allowed the flight to proceed. For more information, see NASA: Lightning and Launches

The perceived value of risk is a recurring topic and is also featured in 795: Conditional Risk and 1252: Increased Risk.



## #2108: Carbonated Beverage Language Map

February 06, 2019



There's one person in Missouri who says "carbo bev" who the entire rest of the country **HATES**.

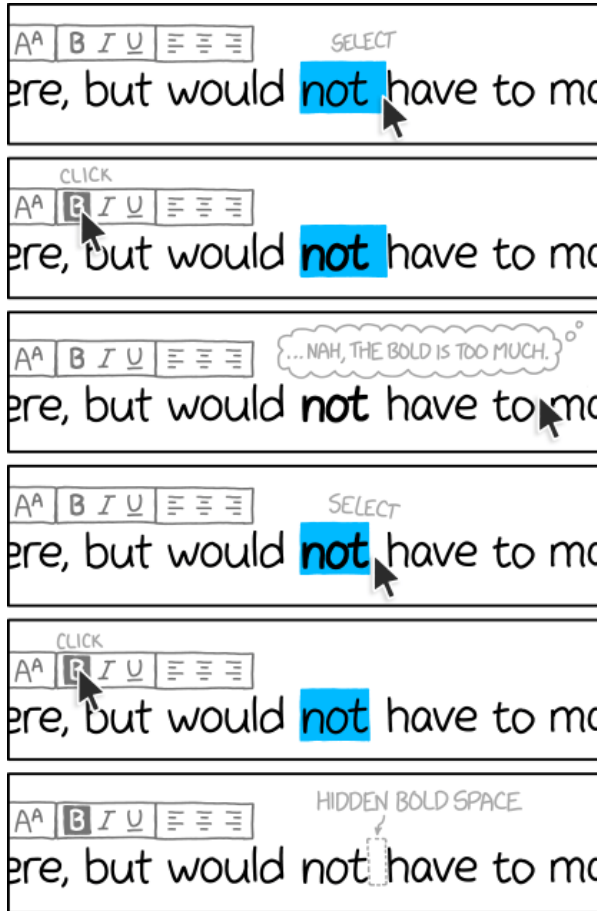
## Explanation

In the US, people in various parts of the country refer to carbonated beverages by different names such as "soda", "pop", "coke", and others. Generally, the West Coast and Northeast say "soda", the South says "coke" and the rest of the country says "pop". There are various maps of where these different names are used, including [popvs soda.com](http://popvs soda.com) and this map on Laughing Squid. Such maps were trending and popular in 2013.

xkcd's map is a satire of those maps – these regional terms are fake. Not only are there far more terms than are actually used by Americans, many are terms for other beverages (mead), unrelated liquids (quicksilver), or trademarked beverage names less popular than Coke/Coca Cola (Code Red) – and in one case, something that's not even tangible ("Crypto").

## #2109: Invisible Formatting

February 08, 2019



WHEN EDITING TEXT, IN THE BACK OF MY MIND I ALWAYS WORRY THAT I'M ADDING INVISIBLE FORMATTING THAT WILL SOMEHOW CAUSE A PROBLEM IN THE DISTANT FUTURE.

To avoid errors like this, we render all text and pipe it through OCR before processing, fixing a handful of irregular bugs by burying them beneath a smooth, uniform layer of bugs.

## Explanation

Most word processor programs allow the user to select sections of text, usually by clicking and dragging the cursor across the text, or by using common mouse shortcuts such as double-clicking to select a word and triple-clicking to select an entire line. The selection is usually indicated by highlighting the text's background, such as the bright blue highlight shown in the comic.

A common reason for selecting text is so that formatting can be applied to the selection (eg. italics or bold formatting). Since space characters are part of the typography, such formatting gets applied to them too; however, as the character has no visible glyph, the formatting has no visible effect (a bold space looks exactly the same as an unformatted space). However, the formatting is still there in the document's underlying markup - it just can't be seen.

This leads to a possibility that a user may accidentally introduce invisible formatting into a document without noticing. Such formatting has no effect on how the end user will read the document, but it could theoretically cause problems for programs that later come along to parse the document, if those programs have not been told to expect formatting. Randall worries about this invisible threat.

In the comic, Randall accidentally introduces the invisible formatting by selecting one more character than

he needed to ("n", "o", "t", and an extra space character), applying bold formatting to those four characters, changing his mind, reselecting only the three characters "n", "o", "t", and removing the bold formatting. Because he failed to notice that a space character had been selected when applying the bold, he failed to remove the bold formatting from the space. As a result, the document now contains an invisible bold space that will likely go unchecked, as nobody can see it to fix it.

There are a couple of ways Randall could have avoided this problem. In many word processors, double-clicking a word will select all characters in the word and nothing else; this is an easier action than trying to drag the cursor, which can be fiddly and inaccurate. This would have prevented Randall from accidentally selecting the space character; although could create the problem if multiple words (and the space(s) between) were initially enboldened but then constituent word-groupings were unenboldened, leaving the whitespace between unreverted. Alternatively, if the program had an "undo" feature, Randall could simply have undone the bold formatting instead of removing the formatting manually. This would have undone the bold formatting on the space character, fixing the problem (and saving time, too), but only presuming that other changes had not occurred in the interim which weren't more important/time-saving to keep.

Though Randall is likely thinking of computer-related problems caused by his invisible formatting, there is also another possible problem: it leaves trace evidence of

Randall's formatting attempt. For example, if an editor later comes along and notices the bold space, they may figure out that Randall originally bolded the word "not" before changing his mind. Depending on the context, a bolded "not" could be enough to change the tone of the text from polite and formal to dismissive (eg. "We believe you are not suitable for this position." vs "We believe you are not suitable for this position.")

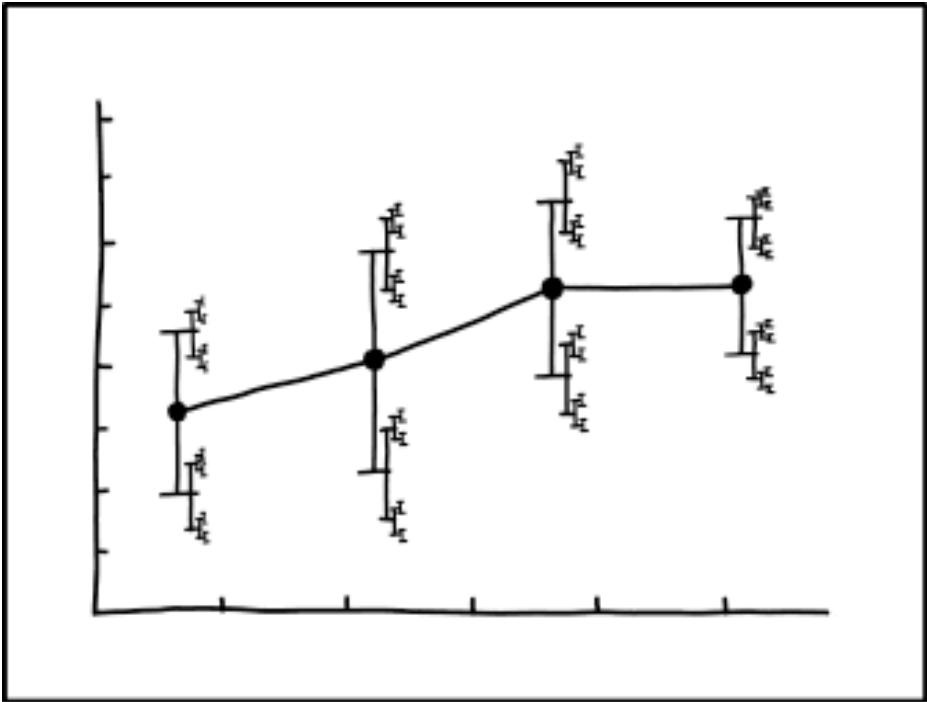
In the title text, Randall says that he fixes such invisible formatting errors by running the text through OCR, which turns images into text. Since OCR uses optical recognition, it would not be able to detect the invisible formatting and would therefore not reproduce it. Although this would "fix" the invisible formatting issue, it would likely introduce a bigger problem: OCR is not 100% reliable at recognizing characters or formatting, and often produces inaccurate results. However, Randall facetiously suggests that this is a preferable state of affairs, as OCR at least produces errors at a reasonably consistent rate, which Randall feels is better than irregular invisible formatting errors.

As the title text explains, Randall finds it very important to control all information he publishes. Real-world examples are governments changing the impact of reports for political reasons. Attempted tampering of this kind can be revealed by bold spaces. Another example would be a casual and short one-sentence reply e.g. to a romantic interest, which one takes one hour to formulate to sound as natural as possible.

There are also other occasions where a hidden bold space may be a problem for later editors (see the Trivia section below). Randall's background in computer programming could also make him more attentive to these types of technical problems, and therefore add this as a reason for his worries about invisible formatting.

## #2110: Error Bars

February 11, 2019



I DON'T KNOW HOW TO PROPAGATE  
ERROR CORRECTLY, SO I JUST PUT  
ERROR BARS ON ALL MY ERROR BARS.

...an effect size of 1.68 (95% CI: 1.56 (95% CI: 1.52 (95% CI:  
1.504 (95% CI: 1.494 (95% CI: 1.488 (95% CI: 1.485 (95% CI:  
1.482 (95% CI: 1.481 (95% CI: 1.4799 (95% CI: 1.4791 (95% CI:  
1.4784...



## Explanation

On statistical charts and graphs, it is common to include error bars showing the probable variation of the actual value from the value shown (or the possible error of the value shown). Since there is always uncertainty in any given measurement, the error bars help an observer evaluate how accurate the data shown is, or the implications if the true value is within the likely error, rather than the exact value shown. There are statistical methods for calculating error bars (they can show a standard deviation, a standard error, or a confidence interval) but the fact that there are multiple ways of calculating them - plus general unfamiliarity with statistical methods - means that people often misinterpret or misunderstand them.

As charts may be of data that has been mathematically processed, the known error from the recording process must also be mathematically processed in order to determine the likely error in the final result - a process called propagation of error. Different transformations of the data result in different transformations of the error, and the correctness of the transformations used can sometimes depend on the subtle differences in the distribution of the source data. At a loss as to how to correctly propagate all the possible sources of error, Randall instead puts error bars on the ends of his error bars to reflect his uncertainty in the original error bars. However, since his second error bar calculations are also suspect, he puts a third set of error bars on them. This

repeats ad infinitum (though only four levels are drawn), creating a fractal-like object.

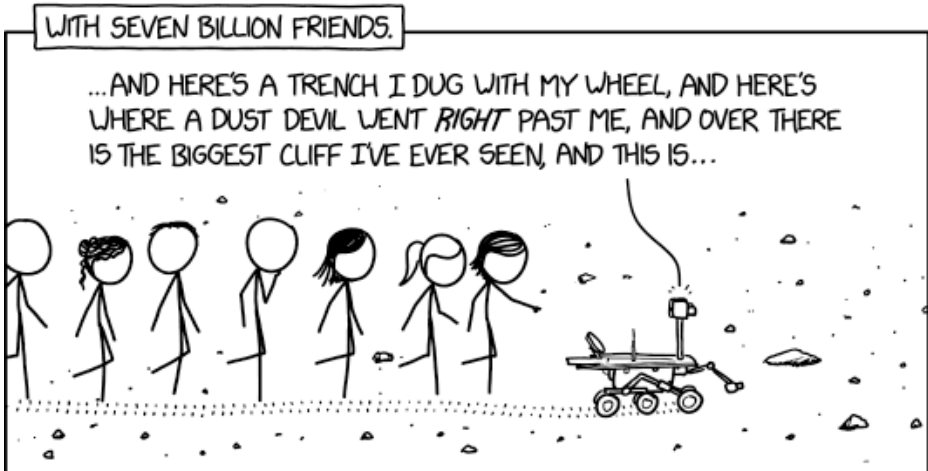
In the title text, he says that the effect size of some variable being calculated is 1.68 and follows it with a 95% confidence interval, or CI (a range of possible values which, under repeated sampling, would contain a number within the interval 95% of the time), which would normally be represented by something like "1.68 (95% CI 1.56 - 1.80)." Since he is stating that those bounds are uncertain, he starts with "1.68 (95% CI 1.56" but then puts the 95% CI for that lower bound of the interval, "95% CI 1.52," followed by the lower bound for that value, "95% CI 1.504," and so on. He goes 11 layers deep before resorting to an ellipsis.

In real life, there is not enough data to compute an error bar on error bars. The data being measured have a sampling distribution, e.g. one might make ten measurements of something which come out to 1, 1, 1.1, 1, 1.4, 1, 1, 0.5, 1, and 1, suggesting it is probably close to 1, so there is a range of values that could likely be. However, properties such as the average and standard deviation do not themselves typically have ranges. If one is uncertain that one has computed these correctly, there is not enough data to compute one's own uncertainty in one's skills in any meaningful way; one can claim error bars on error bars, as in this example, but those are just guesses with no statistically useful backing. One way to make the nested error bars valid might be (if one had the time and money) to run the entire experiment ten times, calculating sigmas each time; then there would be a valid

(although not necessarily useful) sigma on the sigmas. Then one would have to run the set of ten runs ten times for the next "level" of sigmas, etc. The difficulty of doing this entire process, especially when considering that Randall is only nesting error bars out of ignorance, makes this comic all the more absurd.

## #2111: Opportunity Rover

February 13, 2019



Thanks for bringing us along.

## Explanation

This comic is a tribute to the Opportunity rover and its nearly 15 year mission in which it sent back publicly available photos and research from Mars to Earth. The evening prior to this comic uploading (Feb 12, 2019), Nasa's JPL sent their final data request to the rover, in hopes that it would respond. When it did not, the rover was declared to be officially lost.

The comic starts with White Hat, looking at some people taking photographs and lamenting the fact that they're taking pictures all the time, saying "Kids these days...", a common complaint about younger people by their elders. This could be considered a Straw man argument, as White Hat is lamenting that the younger generation look at the world through their camera phones and thus don't experience it directly, and believe that they lose some of the joy of the event in the process - an opinion he has expressed previously in 1314: Photos.

To this Randall appears to counter that sharing and showing to others is an exciting part of the joy, an opinion which he also expressed as Cueball in 1314: Photos. He then proceeds to say that the Opportunity of exploring a completely new world is an exciting part of the exploration, and expresses joy in the fact that MER-B Opportunity was able to share its experiences in its 15-year, 45-kilometer journey on Mars with the entirety of humanity.

The comic ends by thanking the Opportunity rover (and NASA) for allowing the general public the incredible experiences it had on Mars in its 15 Earth-year lifetime, to receive the pictures and data, while traversing along hostile terrain for us. The last panel shows some "followers" which represents everyone on Earth listening to the words from the rover as it transmits the incredible experiences it had on Mars in its 15 Earth-year lifetime. Note, perhaps the reference to "dust devil" suggests these may have been the last such descriptions as that may refer to the deadly global dust storm that likely killed the rover and ended the mission. The dust-devils were also likely responsible for the amazing extended missions for both rovers as they tended to blow the accumulated dust off the solar panels.

The title text shows gratitude for the rover, which brought everyone on Earth, including Randall, along in its journey by sending images of the journey to Earth. Also, Randall used to work at NASA (as a robotocist no less), so as much joy as it brought the world at large, it probably felt just a little more personal for him.

The Opportunity rover also appeared in 1504: Opportunity, while its twin rover Spirit also had a dedicated comic in 695: Spirit.

## #2112: Night Shift

February 15, 2019



MY PHONE HAS A NIGHT SHIFT MODE  
TO HELP ME SLEEP, BUT INSTEAD OF  
REDUCING THE INTENSITY OF BLUE LIGHT,  
IT REDUCES THE INTENSITY OF OPINIONS.

Help, I set my white balance wrong and suddenly everyone is screaming at each other about whether they've been to Colorado.

## Explanation

Many electronic devices have settings to adjust display color and intensity. "Night shift," or similar modes make the display less blue. This may be useful in the evening, since blue light interferes with melatonin, the hormone which regulates the sleep cycle. Exposure to intense blue light in the evening can interfere with becoming sleepy. This comic re-imagines such a mode as influencing the content of messages to encourage sleepiness—or, at least, to dampen the emotional response that might keep someone up too late at night.

In the title text, the reverse has occurred. By setting his white balance incorrectly, the opinions that Randall is reading are more intense, even about "simple" things as having visited Colorado or not (instead of his phone display merely becoming too bluish). This may be a play on angry white male, or similar, which is also characterized by violent expressions of views, and uses the word white. Randall might have meant brightness instead of white balance, with the idea that increasing the amount of light coming from the screen also increases the vehemence of the posts.

This strip then references the fact that on the internet, very few people answer in the singulars of 'Yes' or 'No' or another equally short and definable answer. This may be because there is little perceived value in such a short but factual answer, when you have the opportunity to voice your opinion, sometimes at length. Also in many



cultures indirect expression is the norm, or polite; a short direct answer is considered less acceptable, especially in the negative.

## #2113: Physics Suppression

February 18, 2019



If physics had a mafia, I'm pretty sure the BICEP2 mess would have ended in bloodshed.

## Explanation

White Hat is mad at physicists in general and directs his fury at Megan, a physicist. He has a theory and blames physicists for suppressing it. He believes that no one takes it seriously because his theory would disrupt the standard model in physics. This is a common complaint in pseudoscience, and among amateurs who believe they've made an important discovery and aren't taken seriously. The claim that the scientific establishment sticks to particular orthodoxy and refuses to consider ideas that fall outside it.

Megan responds mockingly to the idea of a "mafia" that suppresses inconvenient science. She points out that, if such an organization existed, they'd "do something about the dark energy people". Dark energy is an unknown form of energy which is hypothesized to permeate all of space, tending to accelerate the expansion of the universe. Dark energy isn't proven to exist, it can't be detected directly, and its nature is unknown, but it's advanced as an explanation of observations which don't conform to accepted theories in physics.

Megan's point is that dark energy (and the data leading to the hypothesis) are exactly the kinds of things that a science mafia would suppress, if one existed. The data and the theory are highly inconvenient to the accepted physical models, and they compel scientists to acknowledge that there are things about the universe that we still don't understand. This is likely why Megan

claims that she's "still mad" at them. And yet, rather than suppress the data or shun people who theorize about it, 2011 Nobel Prize in physics was awarded to a group of researchers for their work on the topic. The point is that scientists, as a group, are fascinated by unexplained results, and celebrate those who manage to develop new models and theories, even where that forces a re-examination of existing theories. The caveat is that those theories need to be supported by evidence and stand up to rigorous examination.

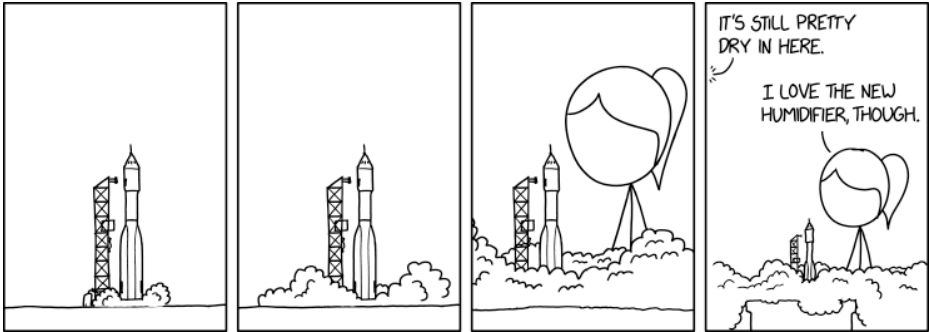
The likely explanation for why White Hat's theory is ignored by physicists is that he can't back it up with evidence, and may not even have a cogent model. He may interpret this rejection as "suppression", but radical new theories are never accepted without clear and convincing evidence. Expecting his theory to be embraced without proof suggests he doesn't understand how basic science works.

The title text mentions BICEP2 (Background Imaging of Cosmic Extragalactic Polarization, 2nd generation) which was part of a series of experiments measuring the polarization of the cosmic microwave background. On 17 March 2014, it was announced, to much fanfare, that BICEP2 had detected signals (B-modes) caused by gravitational waves in the early universe (called primordial gravitational waves). A few years later, this announcement was retracted, as it was found that most, if not all, of the reported signal was actually due to interstellar dust within the Milky Way.

The title text notes that if there had been a physics mafia, then those results would have ended in bloodshed due to the controversy they caused.

## #2114: Launch Conditions

*February 20, 2019*



Though I do think the tiny vent on one of the boosters labeled "O-RING" is in poor taste.

## Explanation

An image of a rocket (resembling a Long March 5) with a progressively larger white cloud around it is shown, but no external object for scale is visible until the third panel.

It is then revealed to be a model or miniature when Ponytail walks into the shot.

The dialog reveals the miniature rocket is a domestic humidifier appliance, using its plumes of water mist to mimic the appearance of the exhaust plume of a full-size rocket.

Modern rocket launches are backed by a Sound Suppression System avoiding damages to the rocket itself, the payload, or humans inside. This system drops vast amounts of water into the exhaust of the rocket engines and the water vaporizes immediately. This vapor mainly interrupts the sound reflections from the ground. This reduces the sound to a level the rocket can withstand but also produces a big cloud of water mist. The cloud at the ground consists mostly of water and not the exhaust of the rocket engines. This article shows how the system works: NASA's Incredible Sound Suppression System Prevents Rockets from Exploding ([interestingengineering.com](http://interestingengineering.com)).

Some rockets use liquid hydrogen as a fuel, especially for upper stages, so steam is the combustion product.

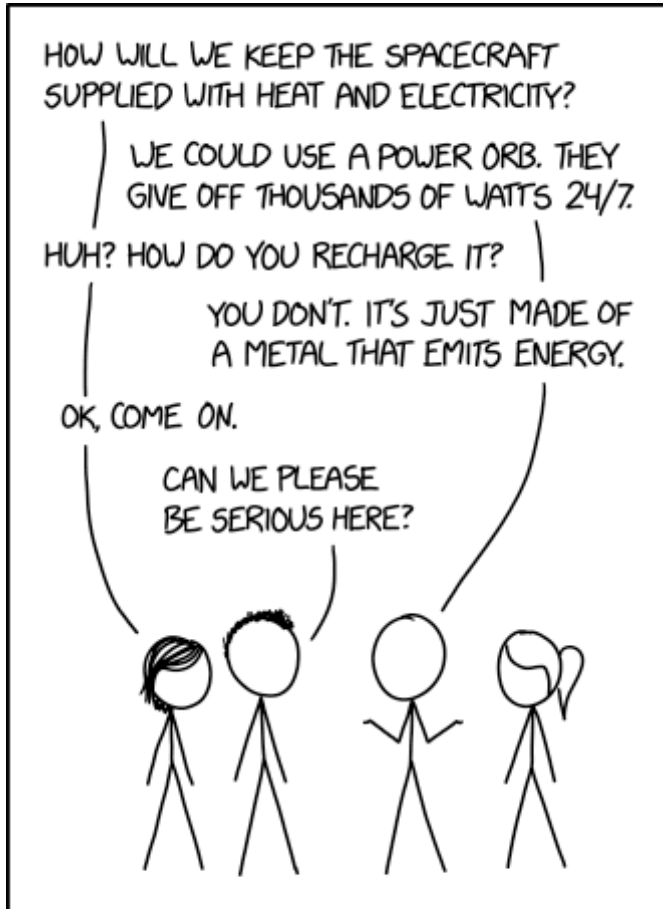
The title text references the failed o-ring that led to the

disintegration of the Challenger Space Shuttle. The o-ring in question failed to expand at freezing temperatures, resulting in a leak of gas around the edges that was visible as a small vapor plume on the recording. The launch was pushed to a day with lower temperatures than the engineers had planned for. For the humidifier to vent the water mist from this opening is indeed in poor taste, even though the model does not resemble a shuttle.



## #2115: Plutonium

February 22, 2019



FOR SOMETHING THAT'S REAL,  
PLUTONIUM IS SO UNREALISTIC.

It's like someone briefly joined the team running the universe, introduced their idea for a cool mechanic, then left, and now everyone is stuck pretending that this wildly unbalanced dynamic makes sense.

## Explanation

This comic pokes fun at the properties of plutonium, claiming that it is so unrealistically powerful that it may as well be random science fiction jargon. Indeed, the ability for a metal to radiate energy sounds impossible. (This comic leaves out the inherent dangers of highly radioactive material.) This is reflected by Megan and Hairy treating Cueball's idea as a joke.

There are devices that need substantial electrical power over long times – on the order of decades – but local sources of energy are insufficient or unavailable, yet constructing a power line or resupplying them with some power source (like fuel, fresh chemical batteries etc.) is either impossible or overly costly. Such devices include maritime beacons and buoys, automatic weather and science stations located in remote areas, and – most importantly – deep space probes and some planetary probes or science packs. A probe sent beyond Jupiter cannot effectively rely on photovoltaic panels for energy because the great distance to the Sun means that the amount of solar radiation per unit of area is very low, requiring impractically large and thus heavy panels to provide enough energy. Carrying a lot of fuel adds mass to the probe, making it more expensive to launch.

Instead, such devices usually use radioisotope thermoelectric generators (RTGs). In an RTG the natural radioactive decay of some unstable isotope such as plutonium-238 or strontium-90 produces a lot of heat.

This is used to generate energy using thermopiles, which generate electricity directly from temperature differences using the thermoelectric effect. The key element of an RTG, a pellet of radioactive material such as plutonium dioxide, could be facetiously described as a "power orb" – a lump of a substance that gives out heat apparently from nothing. For example, the Voyager probes used three RTGs, each containing 4.5 kg of plutonium-238, each producing at its peak 2400 W of heat energy, converted to 160 W of electrical energy.

Plutonium-238 must be produced from neptunium-237 in a nuclear reactor. Neptunium-237 in turn is a "waste product" produced in comparatively large quantities (for something that is essentially real life alchemy, that is) by nuclear reactors. One problem is that in irradiated fuel, neptunium-237 will be mixed in with all sorts of other stuff and separating it is neither cheap nor easy — which is why NASA at one point was in danger of running out of it. Unlike some other radioactive materials, the alpha radiation emitted by plutonium-238 can be relatively harmless, as it is quickly absorbed by surrounding material and turned to heat. But plutonium is still incredibly dangerous if it gets inside a human body unprotected — if the "surrounding material" that turns the alpha radiation into heat is your DNA, you drastically increase your risk for cancer or get radiation sickness, depending on the dose. In pure form plutonium-238 produces a little more than half a watt of heat per gram, which slowly drops as the material decays to lead, emitting a quarter watt per gram after 100 years.

Other disadvantages of RTGs include the risk of contamination in the event of a launch failure, and the relatively limited supply of plutonium.

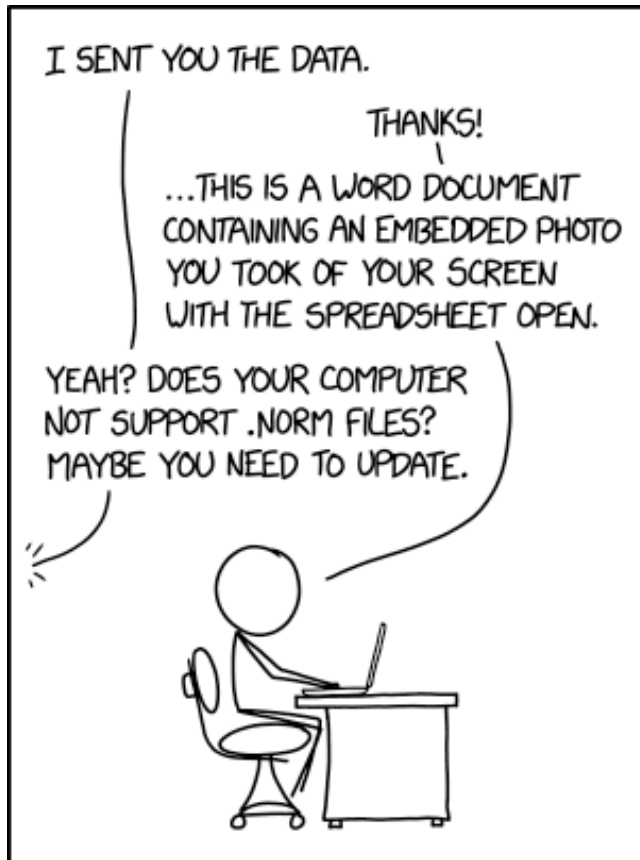
The title text references development of games. A rule or strategy within a game is often called a mechanic, meant as one particular rule (singular) out of the overall set of rules (game mechanics). In this context, the word mechanics is a metaphor referring to the set of rules and interactions that govern the imaginary world of the game. The mechanics of a game define the deterministic or randomized functions of events and/or characters within the game, the outcomes of actions commanded by the players, and so on. This metaphor refers to the mechanics science, and how it describes behavior of physical objects in the real world. However, contrary to real-world mechanics which "just happen" and we try only to describe how things work, in game mechanics every single rule or interaction has to be explicitly defined. The game simulates (to a given extent) an actual world. Game rules do not need to mimic the real world closely and often don't for many reasons; this results in (intended or otherwise) inconsistencies, unexpected behavior or imbalance. Game players complain about "imbalance" when a particular rule, interaction or item present in the game (such as an extremely powerful magical artifact) gives a character exploiting it a great and unjustified advantage. Inconsistencies and possible imbalances can lead to problematic game mechanics being unused or left unresolved, after the creator of those mechanics ceases their participation in the game or game

development process.

Things that seem like they shouldn't work but do are the main topic of 2540: T'TSLTSWBD.

## #2116: .NORM Normal File Format

February 25, 2019



SINCE EVERYONE SENDS STUFF THIS WAY ANYWAY, WE SHOULD JUST FORMALIZE IT AS A STANDARD.

At some point, compression becomes an aesthetic design choice. Luckily, **SVG** is a really flexible format, so there's no reason it can't support vector **JPEG** artifacts.

## Explanation

Information sent by Cueball's friend in this fashion – a photograph of a spreadsheet embedded into a word processing file – is not only aesthetically unpleasing, but essentially useless for any purpose beyond being looked at. The recipient has no choice but to retype the entire data set, or attempt to use optical character recognition (OCR) and hope that no mistakes are made in the process.

Any functional relationships between data (such as formulas used to compute data values) have been lost. Further, the size of the data is bloated by being converted first from numbers and formulas into text, then from text into graphics, and then from graphics to embedded graphics in a word processing document. This adds nothing to the content, and only adds steps to the process of retrieving the data.

However useless this kind of data manipulation might be, it is becoming more and more common, especially as more computer-illiterate people find "creative" ways to exchange information. Usually, their job is getting the data together in a Word file, and the only file they have is a screenshot of the spreadsheet, not the original file, so they just put the screenshot in the Word file. Cueball's friend suggests that this is now a normal way to send files, and that Cueball should update his system to support this new type of file, represented by a ".norm" suffix. In 2341: Scientist Tech Help a .norm like file is referenced.

The caption acknowledges that this has become a de facto standard and that we should just accept and formalize it.

The comic image links to a tweet by OpenElections that displays an Excel file produced by the City of Detroit. It contains a lookup table for the city's absentee precincts in 2016. The data had been input as clip art (images) of the values, instead of being entered in the spreadsheet cells. This comic is reminiscent of the comic 763: Workaround, which also describes convoluted formats.

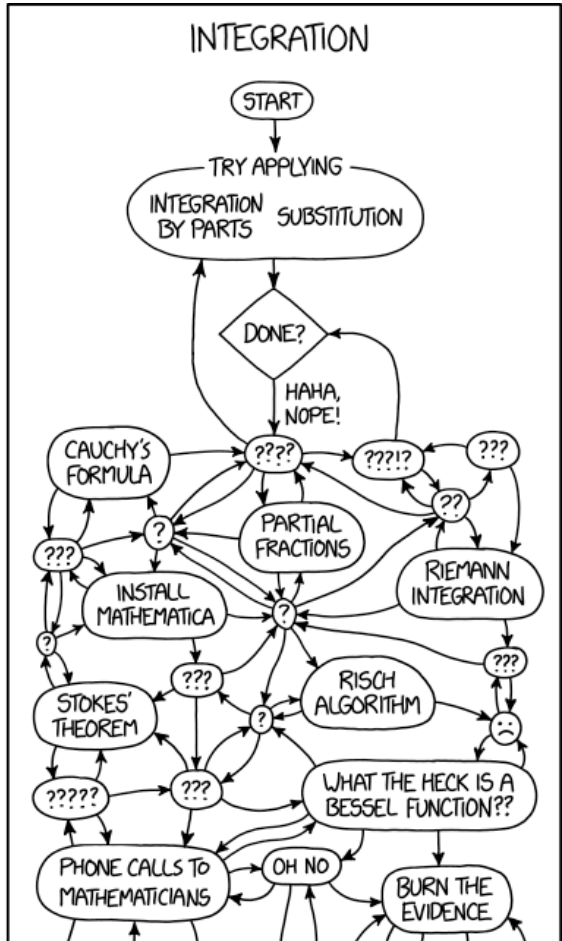
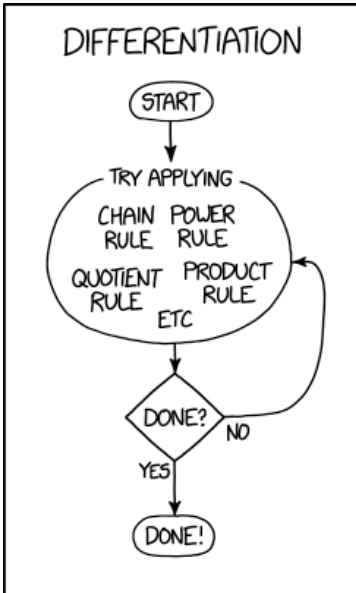
The title text suggests that eventually compression (or at least compression with data/quality loss) will be unnecessary as technology improves in the future. SVG (Scalable Vector Graphics) is a vector graphic format that is fundamentally a lossless format, representing images using geometric figures. JPEG is a lossy format, representing images as an array of rectangles approximating the original image. Randall suggests that some people in the future may choose to include JPEG artifacts to SVG vector graphics for its "aesthetics", perhaps as a throwback to when lower quality JPEG images were commonplace, or as a form of glitch art. It is possible that some in the future will view JPEG artifacts as giving their images a quaint/retro feel, much the way that some people today use sepia-tone filters on their images. (And much like some people today use JPEG artifacts to give their images an intentionally low-quality appearance.) The double space before aesthetic, although likely accidental, is possibly a reference to a bug that could arise when using lossy compression.



This is made even more reasonable by the fact that the SVG specification employs a lot of filters and already can embed regular pixel-based JPEG files. Furthermore, it allows JavaScript to be used to manipulate objects, meaning such an effect may be implementable in the current SVG 2.0 specification.

## #2117: Differentiation and Integration

*February 27, 2019*



"Symbolic integration" is when you theatrically go through the motions of finding integrals, but the actual result you get doesn't matter because it's purely symbolic.

## Explanation

This comic illustrates the old saying "Differentiation is mechanics, integration is art." It does so by providing a flowchart purporting to show the process of differentiation, and another for integration.

Differentiation and Integration are two major components of calculus. As many Calculus 2 students are painfully aware, integration is much more complicated than the differentiation it undoes.

However, Randall dramatically overstates this point here.

After the first step of integration, Randall assumes that any integration can not be solved so simply, and then dives into a step named "????", suggesting that it is unknowable how to proceed. The rest of the flowchart is (we can assume deliberately) even harder to follow, and does not reach a conclusion. This is in contrast to the simple, straightforward flowchart for differentiation. The fact that the arrows in the bottom of the integration part leads to nowhere indicates that "Phone calls to mathematicians", "Oh no" and "Burn the evidence" are not final steps in the difficult journey. The flowchart could be extended by Randall to God-knows-where extents.

It should be noted that Randall slightly undermines his point by providing four different methods, and an "etc", and a "No"-branch for attempting differentiation with no guidelines for selecting between them.

## Differentiation[edit]

Chain rule

For any  $u$  and  $v$ , it follows that  $\frac{d}{dx}(u \cdot v) = u \cdot \frac{dv}{dx} + v \cdot \frac{du}{dx}$ .

Power Rule

For any  $n$ , it follows that  $\frac{d}{dx}(x^n) = n \cdot x^{n-1}$ .

Quotient rule

For any  $u$  and  $v$ , it follows that  $\frac{d}{dx}\left(\frac{u}{v}\right) = \frac{v \cdot \frac{du}{dx} - u \cdot \frac{dv}{dx}}{v^2}$  if  $v \neq 0$ .

Product rule

For any  $u$  and  $v$ , it follows that  $\frac{d}{dx}(u \cdot v) = u \cdot \frac{dv}{dx} + v \cdot \frac{du}{dx}$ .

## Integration[edit]

Integration by parts

The "product rule" run backwards. Since  $\frac{d}{dx}(u \cdot v) = u \cdot \frac{dv}{dx} + v \cdot \frac{du}{dx}$ , it follows that by integrating both sides you get  $\int \frac{d}{dx}(u \cdot v) dx = \int u \cdot \frac{dv}{dx} dx + \int v \cdot \frac{du}{dx} dx$ , which is more commonly written as  $\int u \cdot \frac{dv}{dx} dx = u \cdot v - \int v \cdot \frac{du}{dx} dx$ . By finding appropriate values for functions  $u$  and  $v$  such that your problem is in the form  $\int u \cdot \frac{dv}{dx} dx$ , your problem may be simplified. The catch is, there exists no algorithm for determining what functions they might possibly be, so this approach quickly devolves into a guessing game - this has been the topic of an earlier comic, 1201: Integration by Parts.

Substitution

The "chain rule" run backwards. Since  $\frac{d}{dx}(f(u)) = f'(u) \cdot \frac{du}{dx}$ , it follows that  $f(u) = \int f'(u) \cdot \frac{du}{dx} dx$ . By finding appropriate

values for functions  $f$ ,  $u$  such that your problem is in the form  $\int f(u) \cdot du/dx \cdot dx$ , your problem may be simplified.

## Cauchy's Formula

Cauchy's Integral formula is a result in complex analysis that relates the value of a contour integral in the complex plane to properties of the singularities in the interior of the contour. It is often used to compute integrals on the real line by extending the path of the integral from the real line into the complex plane to apply the formula, then proving that the integral from the parts of the contour not on the real line has value zero.

## Partial Fractions

Partial fractions is a technique for breaking up a function that comprises one polynomial divided by another into a sum of functions comprising constants over the factors of the original denominator, which can easily be integrated into logarithms.

## Install Mathematica

Mathematica is a modern technical computing system spanning most areas. One of its features is to compute mathematical functions. This step in the flowchart is to install and use Mathematica to do the integration for you. Here is a description about the intricacies of integration and how Mathematica handles those. (It would be quicker to try Wolfram Alpha instead of installing Mathematica, which uses the same backend for mathematical calculations.)

## Riemann Integration

The Riemann integral is a definition of definite integration. Elementary textbooks on calculus sometimes present finding a definite integral as a process of approximating an area by strips of equal width, as in , and then taking the limit as the strips become narrower. Riemann integration removes the requirement that the strips have equal width, and so is a more flexible definition. However there are still many functions for which the Riemann integral doesn't converge, and consideration of these functions leads to the Lebesgue integral. Riemann integration is not a method of calculus appropriate for finding the anti-derivative of an elementary function.

### Stokes' Theorem

Stokes' theorem is a statement about the integration of differential forms on manifolds. It is invoked in science and engineering during control volume analysis (that is, to track the rate of change of a quantity within a control volume, it suffices to track the fluxes in and out of the control volume boundary), but is rarely used directly (and even when it is used directly, the functions that are most frequently used in science and engineering are well-behaved, like sinusoids and polynomials).

### Risch Algorithm

The Risch algorithm is a notoriously complex procedure that, given a certain class of symbolic integrand, either finds a symbolic integral or proves that no elementary integral exists. (Technically it is only a semi-algorithm, and cannot produce an answer unless it can determine if a certain symbolic expression is equal to 0 or not.) Many computer algebra systems have chosen to implement only the simpler Risch-Norman algorithm, which does not come

with the same guarantee. A series of extensions to the Risch algorithm extend the class of allowable functions to include (at least) the error function and the logarithmic integral. A human would have to be pretty desperate to attempt this (presumably) by hand.

## Bessel function

Bessel functions are the solution to the differential equation  $x^2 \cdot d^2y/dx^2 + x \cdot dy/dx + (x^2 - n^2) \cdot y = 0$ , where  $n$  is the order of the Bessel function. Though such functions show up in some engineering, physics, and abstract mathematics, in lower levels of calculus they are often a sign that the integration was not set up properly before someone put them into a symbolic algebra solver.

## Phone calls to mathematicians

This step would indicate that the flowchart user, desperate from failed attempts to solve the problem, contacts some more skilled mathematicians by phone, and presumably asks them for help. The connected steps of "Oh no", "What the heck is a Bessel function?" and "Burn the evidence" may suggest the possibility that this interaction might not play out very well and could even get the caller in trouble.

Specialists and renowned experts being bothered - not to their amusement - by strangers, often at highly inconvenient times or locations, is a common comedic trope, also previously utilized by xkcd (for example in 163: Donald Knuth).

## Burn the evidence

This phrase parodies a common trope in detective fiction, where

characters burn notes, receipts, passports, etc. to maintain secrecy. This may refer to the burning of one's work to avoid the shame of being associated with such a badly failed attempt to solve the given integration problem. Moreover, such a poor attempt at integration could be viewed as a 'crime against mathematics', with the working of the problem being criminal 'evidence' that must be destroyed to avoid exposure as the culprit. Alternatively, it could be an ironic hint to the fact that in order to find the integral, it may even be necessary to break the law or upset higher powers, so the negative consequences of a prosecution can only be avoided by destroying the evidence.

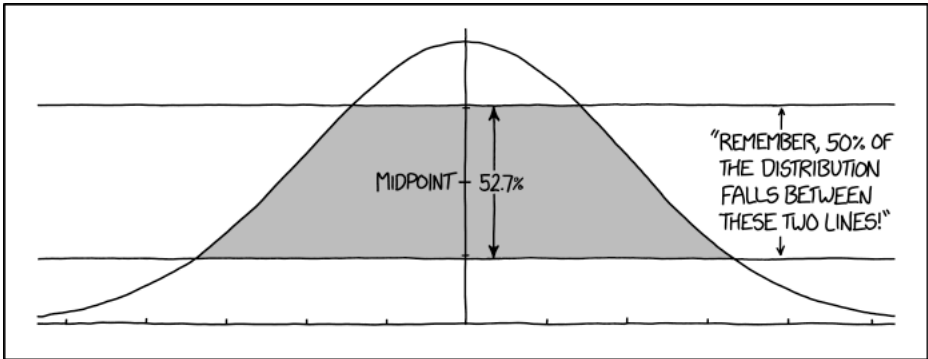
### Symbolic integration

Symbolic integration is the basic process of finding an antiderivative function (defined with symbols), as opposed to numerically integrating a function. The title text is a pun that defines the term not as integration that works with symbols, but rather as integration as a symbolic act, as if it were a component of a ritual. A symbolic act in a ritual is an act meant to evoke something else, such as burning a wooden figurine of a person to represent one's hatred of that person. Alternatively, the reference could be seen as a joke that integration might as well be a symbol, like in a novel, because Randall can't get any meaningful results from his analysis.



## #2118: Normal Distribution

March 01, 2019



HOW TO ANNOY A STATISTICIAN

It's the **NORMAL** distribution, not the **TANGENT** distribution.

## Explanation

This is another comic on How to annoy people, particularly targeting statisticians in this instance.

In statistics, a distribution is a representation that can be understood in terms of how much of a sample is expected to fall into either discrete bins or between particular ranges of values. For example, if you wanted to represent an age distribution using bins of ten years (0-9, 10-19, etc.), you could produce a bar chart, one bar for each bin, where the height of each bar represents a count of the portion of the sample matching that bin. To turn that bar chart into a distribution, you'd get infinitely many people (technically: a number  $N$  which tends to infinity), put them into age bins that are infinitely narrow (technically: bins whose size is  $O(1/\sqrt{N})$ ), and then divide each bin count by the total count so that the whole thing added up to 1. It is common to ask how much of the distribution lies between two vertical lines; that would correspond to asking what percent of people are expected to fall between two ages.

Many statistical samplings resemble a pattern called a "normal distribution". A theoretically perfect normal distribution would have an infinite sample size and infinitely small bins. That would produce a bar chart matching the shape of the curve in the comic.

The area between two vertical lines of the distribution

represents the probability that a randomly selected X-value is between the X-values of the lines. Randall instead finds the area between two horizontal lines, which is mathematically meaningless, because the Y-axis of a probability distribution is typically taken to represent magnitude as a fraction of unity. In the age-distribution analogy above, two points with the same X-value could be understood to represent two people with the same age; but two points with the same Y-value cannot easily be understood in terms of the analogy. The items "represented" by the magnitude at any given horizontal position are indistinguishable, unordered, and interchangeable; the fact that two items happen to fall at the same position on the Y-axis doesn't mean they have anything in common.

In short, Randall has invented a new probability distribution, which the title text humorously implies should be called the tangent distribution. This distribution is defined as follows: consider the area between the curve in the comic and the horizontal axis, and consider a random point  $(X, Y)$  uniformly distributed in that region. Then  $X$  has the normal distribution and  $Y$  has the tangent distribution. Areas between vertical lines in the comic give probabilities concerning  $X$ , and areas between horizontal lines in the comic give probabilities concerning  $Y$ . The comic correctly indicates that if we let  $R$  be the interval of  $Y$  values that is 52.682% of the range of  $Y$  centered at the midpoint of the range, then any randomly selected  $Y$  value has probability  $1/2$  of falling inside interval  $R$ .

This distribution has never been discussed before, and has no known application. Moreover, the distribution of  $Y$  is not symmetric: while 50% of  $Y$  values fall inside interval  $R$ , 41% fall below  $R$  and only 9% fall above  $R$ . So the single piece of information in the comic is not a good way to describe this distribution! We do use such intervals for the normal distribution because the normal distribution is symmetric, and the center of symmetry is the mean, median, and mode. (However, it would be just about as ridiculous to observe that 50% of the  $X$  values in a standard normal distribution fall between the vertical lines  $X=-0.2$  and  $X=1.41$ .)

The title text refers to the notion of normals and tangents in geometry. Given a 2D curve or 3D surface, a line which points perpendicularly outward from a point on the curve or surface (making a 90-degree angle with the curve) is said to be normal to the curve, while a line which just grazes the curve, being exactly parallel to the curve at the point of contact, is said to be tangent to the curve at that point. The joke is that this geometrical notion of normal is completely unrelated to the statistical normal distribution. Randall observes that if you take a geometric normal and rotate it 90 degrees, you produce a tangent; thus, if you take the normal distribution and rotate it by 90 degrees, you must get something called the "tangent distribution." Saying this to a statistician would only annoy the statistician further.

This is annoying to a statistician not only because the terms normal and tangent come from differential geometry and have no established meaning in probability

theory. Even the word perpendicular has no established meaning in probability theory. Of course, the  $x$  and  $y$  coordinates in the comic are perpendicular (orthogonal) coordinates, but  $X$  and  $Y$  are not "perpendicular" or "orthogonal" random variables. Even if we give "perpendicular" or "orthogonal" a probabilistic meaning, and the most obvious such meaning is either independent, which even uses a symbol related to the geometric symbol for perpendicularity, or uncorrelated, which makes  $X$  and  $Y$  orthogonal vectors in the Hilbert space of random variables that are square integrable with respect to Lebesgue measure,  $X$  and  $Y$  are not perpendicular in either of these senses.

So the more probability and statistics you know, the more annoying this comic becomes. It is not just about confusing novices.

## #2119: Video Orientation

March 04, 2019

### VIDEO ORIENTATION

#### HORIZONTAL



#### VERTICAL



#### DIAGONAL



### PROS

- LOOKS NORMAL TO OLD PEOPLE
- FORMAT USED BY A CENTURY OF CINEMA
- HOW MOST NORMAL PEOPLE SHOOT AND WATCH VIDEO NOW SO WE MAY AS WELL ACCEPT IT
- BOLD AND DYNAMIC
- EQUALLY ANNOYING TO ALL VIEWERS
- GOOD COMPROMISE

### CONS

- HUMANS ARE TALLER THAN THEY ARE WIDE
- I'M NOT TURNING MY PHONE SIDEWAYS
- HUMAN WORLD IS MOSTLY A HORIZONTAL PLANE
- NONE

**CIRCULAR VIDEO - PROS:** Solves aspect ratio problem. **CONS:** Never trust anyone who talks to you from inside a circle.

## Explanation

This comic compares selected pros and cons of 3 video "orientations" (also known as angling), one of which is entirely made-up. This comic could have been inspired by articles published by Mashable, and Scientific American, which comment on how videos are now filmed vertically through smartphones.

Randall's observations on horizontal vs vertical indicate that he has resigned himself to the acceptance of vertical videos. However, he does love a good compromise, so he suggests "Diagonal Orientation" as a third option to equally dissatisfy both types of user. The issue with this is that diagonal angling fails to fully capture the benefits of either horizontal or vertical angling.

This is another comic claiming that an obviously bad idea keeps being done by accident "so we might as well just accept it", following on from 2116: .NORM Normal File Format a week prior.

Horizontal orientation

Pros:

- Good for people not used to phones, and has been used for over a century for capturing video.
- Easier to control the composition of the image, especially wide shots.
- Main distribution format for most video types.

Cons:

- Not the best at capturing a human's entire body, without also capturing much of their surroundings.
- Potentially uncomfortable for the one making the recording to maintain over a long period of time, as most phones were designed for vertical holding.

Vertical orientation

Pros:

- Supposedly the norm for most users capturing video on their smartphone (thus we should accept it as such).
- Made for mobile devices by design. This means you can quickly post to multiple channels with a single video with no need for complicated editing or tweaking.

Cons:

- Not ideal for capturing the background, as our world is mostly a "horizontal plane".
- Limits techniques you can use, for example it restricts the way you can compose shots, scan the landscape, and present different scenes.

Diagonal orientation

Pros:

- Not a standard format of video, thus "bold". It's "dynamic" since it can capture significant portions of both human and landscape.



- Equally annoying to all viewers.
- Flawless, as in perfect in every way.[dubious]

Cons:

- None.

The diagonal orientation is similar to the "oblique angle" or "Dutch angle" in cinema, and is often used to portray psychological uneasiness or tension in the subject being filmed. Note that while "Dutch angle" is filmed diagonally, it is projected in the classic Horizontal orientation.

Circular video

Pros:

- Solves the aspect ratio problem, as it will always be 1:1.

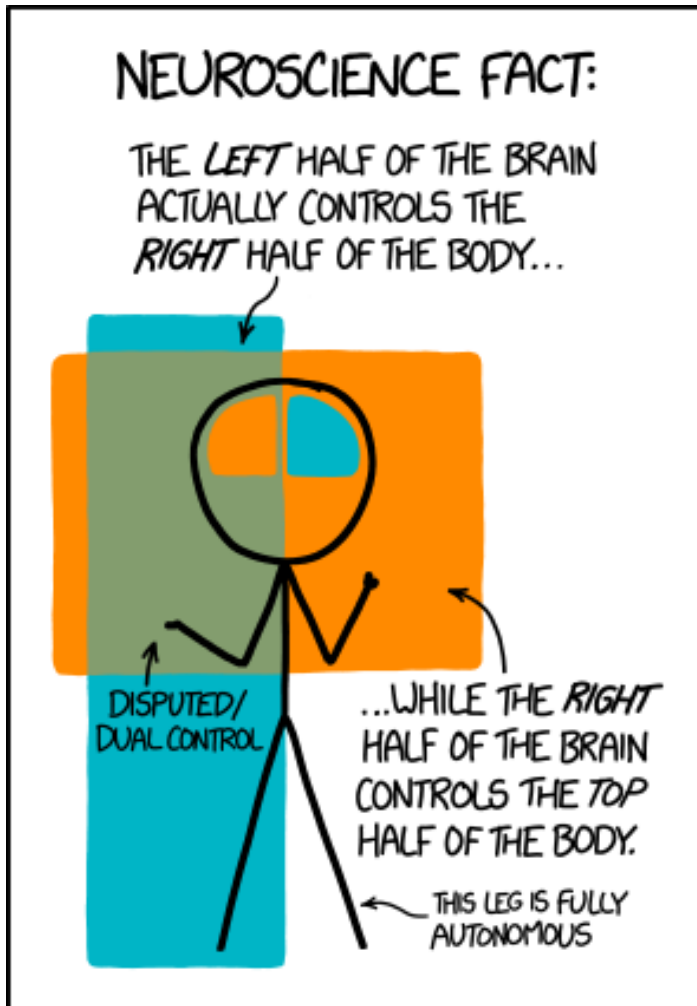
Cons:

- The title text quip about non-trustworthy opinions from someone inside a circle could be a nonsense statement, or refer to various things, such as having a demon trapped inside a summoning circle; being spoken to by members of a select or secretive circle of people; HAL 9000 from 2001: A Space Odyssey; Loki in The Avengers, who is the god of trickery and is held at one point in a circular cell; an advertising trope where a talking head in a circle is superimposed over images of the product being advertised, usually this is the case in low budget productions for "as seen on TV"

products.

## #2120: Brain Hemispheres

March 06, 2019



Neurologically speaking, the **LEFT** hand is actually the one at the end of the **RIGHT** arm.

## Explanation

As a general rule, each cerebral hemisphere controls the opposite side of the body; things on the left half of the body are controlled by the right side of the brain and vice-versa. Biology is complicated,[citation needed] of course, so as with most biology "rules" there are exceptions, such as the cranial nerves, but it's true for most motor functions, if not strictly correct in all cases.

Randall spoofs this by saying that rather than controlling the left half of the body, the right brain controls the top. This Euler-diagram-like picture echoes maps that display a territorial dispute, suggesting that the halves of your brain fight for control of the region, or "dual control" like in an airplane, where the pilot and the copilot both can control the plane at any time. The reorganization also leaves a gap in the bottom left, implying that the left leg is not controlled by any part of the brain, and instead has a mind of its own.

The title text proposes that the hands should be referred to not by their physical location, but by the hemisphere of the brain they're connected to. Of course, this is not only silly but inconsistent: if the hands were labelled by hemispheres of the brain, the same would presumably apply to the arms. Furthermore, there would be no reason to give left/right names to the hemispheres themselves, since their placement in the skull would be irrelevant.

## #2121: Light Pollution

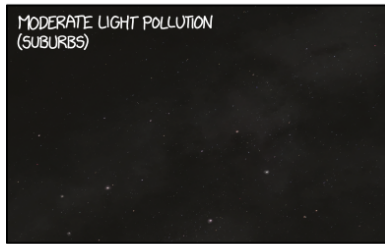
*March 08, 2019*

LIGHT POLLUTION AND THE DISAPPEARING NIGHT SKY

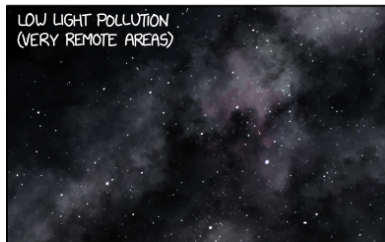
HIGH LIGHT POLLUTION  
(CITIES)



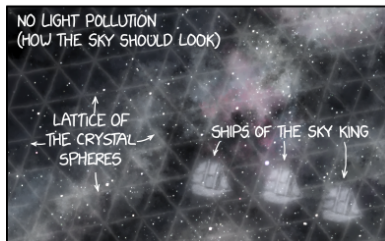
MODERATE LIGHT POLLUTION  
(SUBURBS)



LOW LIGHT POLLUTION  
(VERY REMOTE AREAS)



NO LIGHT POLLUTION  
(HOW THE SKY SHOULD LOOK)



It's so sad how almost no one alive today can remember seeing the galactic rainbow, the insanity nebula, or the skull and glowing eyes of the Destroyer of Sagittarius.

## Explanation

This comic shows how light pollution in cities affects what you can see from the night sky. The first three panels show realistic examples of what you could see from the sky inside a large city, in the suburbs and far away from light pollution. These panels roughly correlate on the Bortle Scale to 8-9 (city), 5-6 (suburbs) and 2-3 (remote area).

The last panel contrasts these for comedic effect with fake things that are not actually present in the night sky.[citation needed] The "Ships of the Sky King" may be a reference to an elven legend in J. R. R. Tolkien's works, in which several elven ships sail tangentially off the planet of Middle Earth and into the sky. This story was previously mentioned in 1255: Columbus. "Crystal spheres" is an ancient theory about the heavens and what it was that held up the stars, before it was commonly accepted that space could be made of hard vacuum and celestial bodies held there by laws of inertia and gravity and vast distances. The spheres are nested inside each other concentrically. Randall proposes they are held by latticework like that which supports the Eiffel Tower, and that the lattice structure could be seen long ago when the sky was much darker. It is also a possible reference to the science fiction short-story "The Crystal Spheres" by David Brin, where the solar system is surrounded by hard crystal spheres that have to be broken before leaving as an explanation of the Fermi Paradox. Furthermore, in the lore of Dungeons &

Dragons, the solar system is also enclosed in a massive crystal sphere, with other solar systems in similar solar systems, separated by "the flow".

Although all crystals do have a crystal lattice, as in the meaning 3 of the word "crystal" in Merriam-Webster (a body that [...] has a regularly repeating internal arrangement of its atoms and often external plane faces), these lattices are sub-microscopic and would be invisible in the sky. Additionally, crystal structure was not yet known at the time that the celestial spheres theory was popular. Crystal Spheres were also mentioned in 1189: Voyager 1.

In consensus reality, the sky does contain many invisible objects that can observe us and/or provide major structures of our society, such as satellites, nearcraft, and drones, but these are usually invisible due to size and distance more than brightness.

The title text starts off sounding like a legitimate statement about light pollution. It is common to remark that the vast majority of people never see things in the night sky that were commonly seen by our ancestors every night prior to industrialization, such as the Milky Way or now-obscure phenomena such as Zodiacal light, Airglow or Gegenschein. The title text then further adds to the humor of the last panel by describing non-existent features, which could be references to H. P. Lovecraft as he often refers to beasts the possible size that "The Destroyer of Sagittarius" would have to be (Sagittarius is one of the constellations of the zodiac and Sagittarius A\*

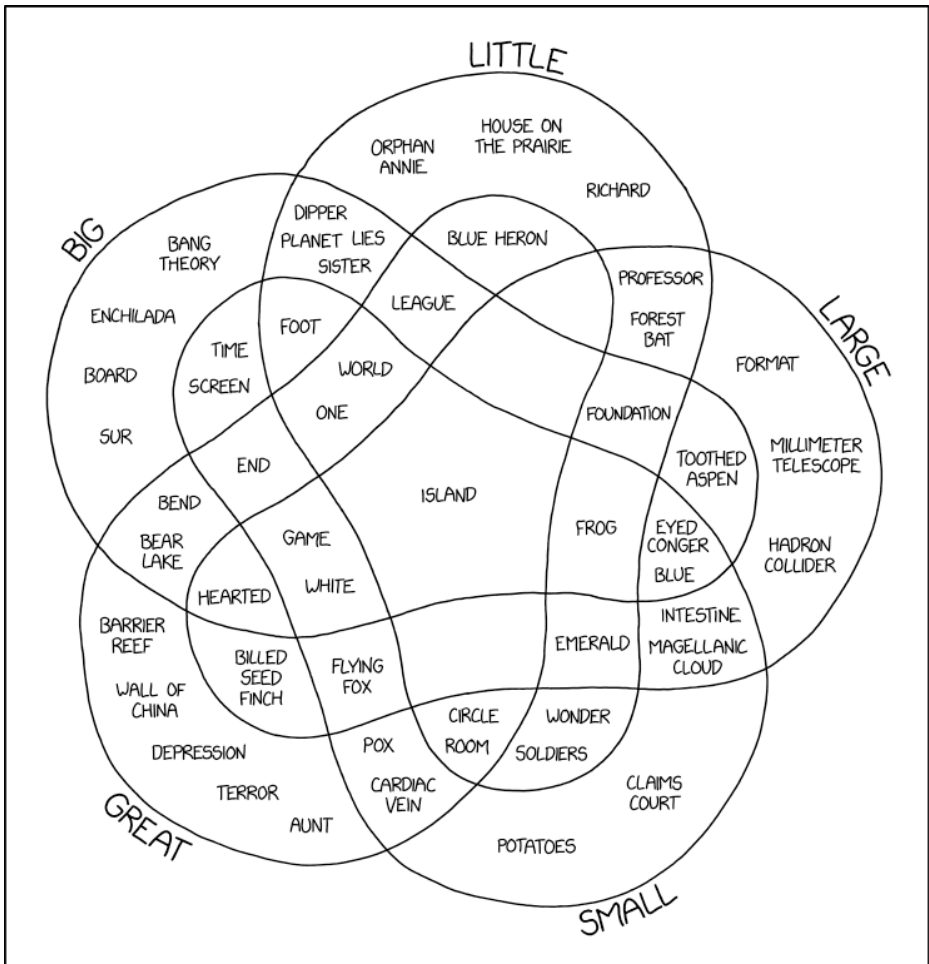
a black hole at the center of the Milky Way inside of that constellation.). He also often speaks of insanity and color, connecting the two.

Light pollution was later mentioned in 2274: Stargazing 3.



## #2122: Size Venn Diagram

March 11, 2019



Terms I'm going to start using: The Large Dipper, great potatoes, the Big Hadron Collider, and Large Orphan Annie.

## Explanation

This comic is a Venn diagram illustrating the complete set of possible intersections of five different size adjectives: "little", "large", "small", "great" and "big". Each unique intersection contains a short list of nouns that can be preceded by each of its intersecting adjectives.

For example, "flying fox" (a type of bat) appears at the intersection of "large", "small", and "great", because the species large flying fox, small flying fox, and great flying fox all exist, but there is no such species as a "big flying fox" or a "little flying fox". Similarly, humans have organs named the small intestine and large intestine, but no "little intestine", "great intestine", or "big intestine".

Some descriptors are applied in combination to their noun, rather than individually; for example, "planet" is placed in both the "little" and "big" groups in reference to the 2008 video game Little Big Planet.

In the title text, Randall declares that he will start intentionally using term combinations that don't appear in the above diagram, presumably to ensure every intersection contains at least one term. A slightly more reasonable solution is to publish books/songs/films/etc under these titles (details needed), as many of the entries in this comic are titles.

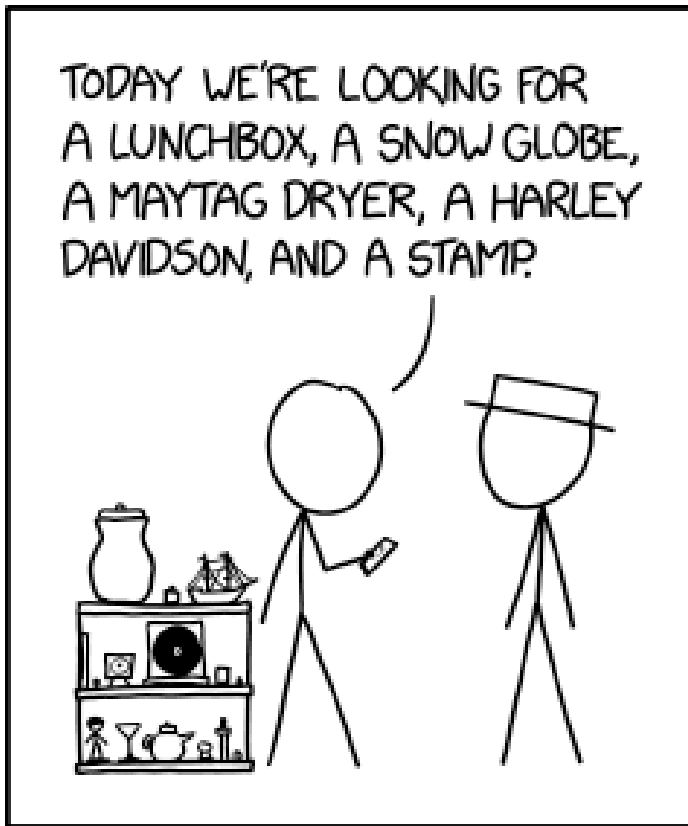
A similar concept can be seen in 181: Interblag, but in a tabular form rather than a Venn diagram.

**List of items in the diagram[edit]**

The following table lists all size/noun combinations that the Venn diagram can generate, with a description of each.

## #2123: Meta Collecting

March 13, 2019



MY HOBBY: COLLECTING ONE ITEM  
FROM EVERY CATEGORY LISTED ON  
WIKIPEDIA'S "LIST OF COLLECTABLES."

I'm trying to get the page locked because some jerk keeps adding "Yachts".

## Explanation

This is another comic in the "My Hobby" series.

Many people's hobbies involve collecting many items of the same category: Post stamps, collectible cards, painted dolls, wine, and so on. Just about anything can be collected, however, some things are collected much more often than others. Wikipedia has a page listing the most popular categories of such collectible items.

In Randall's usual style of going meta with everything, he decided to start a meta-collection—a collection of examples of different things that people can collect. He uses Wikipedia's list of collectibles for reference. In the comic, Cueball is showing to his friend his collection of various items that have nothing in common except that they're all popular collectibles. So while most people try to collect everything in one narrow category of collectibles, Cueball's collection will only be complete if he can get one item from each of the list of collectible items as cataloged by Wikipedia's list, so he has a collection of representative elements from all collections.

In the title text, Randall complains about a Wikipedia editor who keeps adding yachts to the list of collectibles, probably because it would force him to buy a yacht if he ever wanted to complete his collection of collectibles. Yachts are traditionally considered immensely expensive and the vast majority of people own zero yachts, let alone a collection of them.[citation needed] Note that Randall

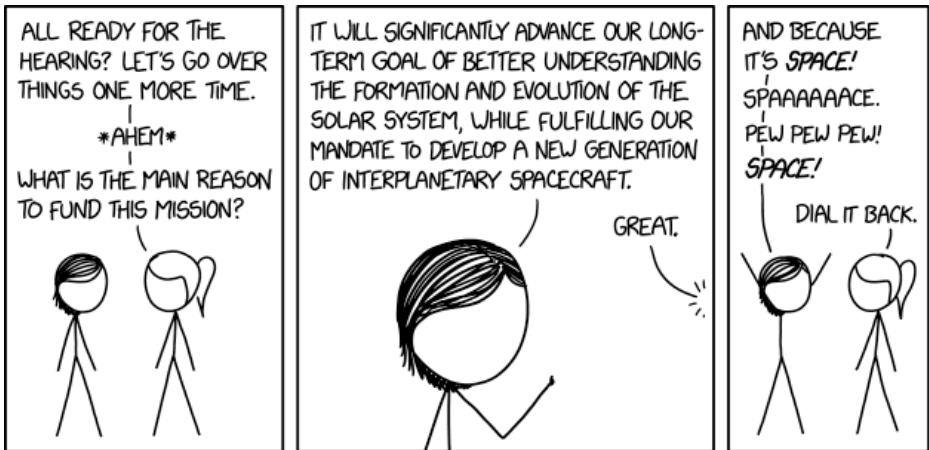
does not specify how he is trying to get the page locked, and the comic itself might be a rather meta way of doing so: xkcd fans have a history of making lots of edits to Wikipedia articles Randall mentions, resulting in them being protected or locked. The article has in fact been edited and reverted about 50 times by these fans over the course of a single day and was temporarily protected on March 14th, 2019, which expired three days later. The first addition of Yachts to this page was by a user named Xkcd2123, but it is unlikely that this user is Randall.

### **List of Items on the Shelf[edit]**

Items are numbered on each shelf from left.

## #2124: Space Mission Hearing

March 15, 2019



Our grant application contains one of those little greeting card speakers that plays spaceship noises when you open it.

## Explanation

Megan and Ponytail are organizers of a space mission going over their upcoming presentation to a hearing that will approve the mission's funding. Megan recites the grown-up, professional, scientific justification for the mission, but soon her enthusiastic and nerdy attitude toward space breaks through, and she exclaims "space" and "pew pew pew" (An internet meme for the sound of lasers, inspired as a typical sound that media space weapons make, and now an onomatopoeia often used in gaming speak for ray weapons and spells as a joke) with childish abandon. Ponytail wants her to rein in her enthusiasm during the actual hearing as the funding is unlikely to come if they are behaving childishly instead of being professional.

The joke is that most of the motivation people working in space agencies have for spending billions of dollars and other resources on interplanetary exploration is not really for all the stuffy reasons listed, but simply because they believe space is cool. Funnily, due to the vacuum in space, you would actually not hear sounds and so some part of the enthusiasm is entirely childish.

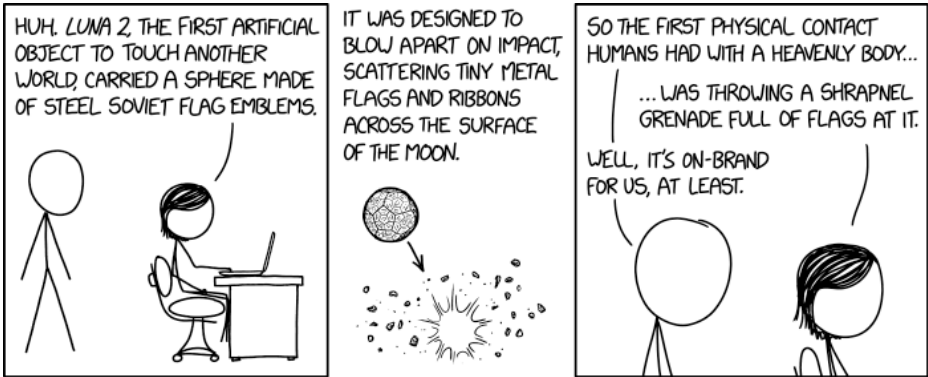
The title text refers to a repurposable piece of electronics contained within specific greeting cards, which plays a prerecorded song when the card is opened. Usually, these cards play a song, like "Happy Birthday", when they are opened. Apparently, their grant application has incorporated speakers which play "spaceship noises", in



order to stimulate excitement about the coolness of space in the receiver which is in contrast to the business-like atmosphere that a mission hearing would normally have. An additional joke is that the card will likely hurt their chances to get the funding instead of stimulating excitement in the receiver.

## #2125: Luna 2

March 18, 2019



The flags were probably vaporized on impact, because we launched it before we had finished figuring out how to land. That makes sense from an engineering standpoint, but also feels like a metaphor.

## Explanation

This comic is referring to Luna 2, the first man-made object to make contact with the surface of the moon, and consequently, as stated in the comic, the first man-made object to touch another world. On September 13, 1959, it hit the Moon's surface east of Mare Imbrium near the craters Aristides, Archimedes, and Autolycus.

Megan is sitting in front of a computer, and telling Cueball about the Luna 2. She shows a picture of the probe and explains that the probe was designed to explode on impact, thus scattering multiple metal Soviet flags and ribbons on the surface of the Moon. They compare it to throwing a shrapnel grenade with flags in it at the moon (see Trivia).

In truth, the idea behind the two explosive spheres was rather clever. The spacecraft arrived at the moon at more than 3 km/s - and with uncontrolled orientation. But no matter which orientation that these spheres were in as they arrived at the moon, the force of the explosion would cause the commemorative plaques nearest to the direction of motion to be thrown even faster at the moon (and, presumably, be vaporized) - while the ones from the opposite side of the sphere would be slowed down by the force of the explosion and might possibly arrive at the surface intact.

Cueball's observation that it is "on-brand" for humans to litter another world with an explosion of nationalist

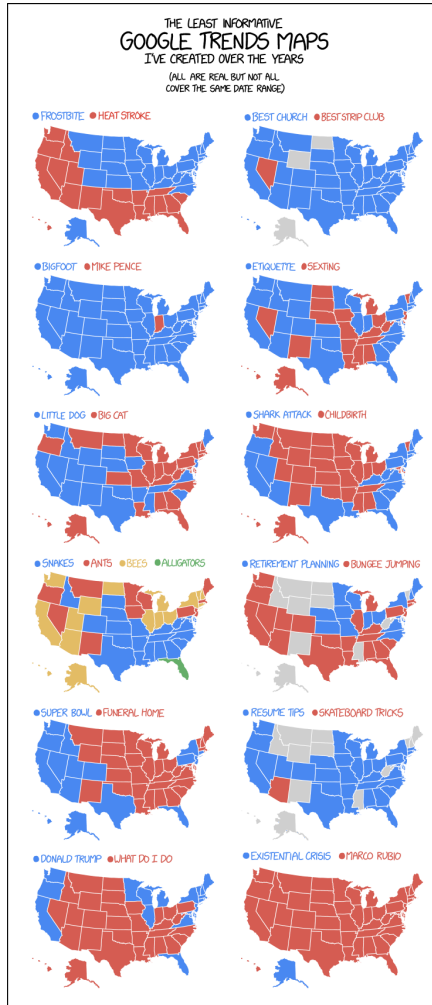
iconography immediately upon reaching it, is a reference to the vastly numerous historical instances when, upon setting foot on territory for the first time, humans "conquer" it, by planting flags on the first thing they see. Alternately, it may be "on-brand" for humanity's first interaction with a new object to be striking it with a weapon.

The title text refers to the fact that for the Luna 2 mission it was more important to just get to the moon at all rather than have a sophisticated landing mechanism. This was due to the fact that it happened during the space race between the USA and USSR and both countries tried to reach significant milestones in space exploration. The metaphorical interpretation is that sometimes people get overly excited after an initial breakthrough and dive into projects without thinking them through or considering long term consequences. This often leads to the project failing or barely achieving its aim. This often goes along with the confidence to be able to "wing it" making up a solution on the spot when a problem comes up. It may also refer to how immediately after traveling to the moon, humanity will die.

Note that Randall makes a subtle yet strong declaration that he is an engineer, a human, and an Earthling first, and American second, by saying "we" in the title text, regarding this effort to reach the Moon.

## #2126: Google Trends Maps

March 20, 2019



It's early 2020. The entire country is gripped with Marco Rubio fever except for Alaska, which is freaking out. You're frantically studying up on etiquette and/or sexting.

## Explanation

Google Trends is a website for visualizing Google search activity by date and region. Used properly, it can give a picture of what topics people are interested in (as evidenced by what they search for) at particular times and in different places. Used improperly, it can simply amplify random noise.

Randall has created several Google Trends maps of search activity in the US. Each map colors in states according to which of two (or more) search queries was more popular. As noted at the top of the comic, all of these based on real queries (though not reflecting the same time period across all maps). However, none of them seem to show any especially useful comparisons. States in gray did not return enough data for Google Trends to consider it significant.

- "Frostbite" vs "heat stroke": This is probably the most sensible comparison of the lot, showing which of these two risks of exposure people search up more often. However, the results are fairly obvious: in the colder northern and eastern states, "frostbite" is the more common search, while across the south and west, it's "heat stroke". In the map, a tiny part of North Carolina (specifically on the Outer Banks) is miscolored red compared to the rest of the state being blue.
- "Best church" vs "best strip club": This map would seem to indicate people in Nevada (and only in Nevada) are

more interested in strip clubs than religion. This may have something to do with the fact that Las Vegas is in Nevada.

- "Bigfoot" vs "Mike Pence": Apparently, everywhere except for Indiana, people in the US are more interested in a mythical hairy creature than in the current (at the time of this comic's release) Vice President of the United States. Since Mike Pence was once the governor of Indiana, this makes more sense if the time period covered precedes his nomination as Trump's running mate.
- "Etiquette" vs "sexting": Similar to the church/strip club example, this map contrasts search interest in polite behavior (etiquette) against risqué behavior (sexting).
- "Little dog" vs "big cat": The Trend map contrasts two searches for either oddly-sized pets (in particular, "little dog" probably refers to small domestic dog breeds such as the Chihuahua; "big cat" could refer to large domestic cat breeds such as the Maine Coone, but is somewhat more likely to refer to large wildcat species) or unidentified and briefly glimpsed wildlife that often snatch household pets left outside. The smallest canid in the wilds of America is the kit fox, *Vulpes macrotis*, which is smaller than the American wild dog, *Canis lupus familiaris*. By contrast, "big cat" is a term for the largest members of the cat family (Felidae). Except for the jaguar, which is a roaring cat of the *Panthera* genus that inhabits Mexico and sometimes Arizona, the largest wild cat in North America is the mountain lion, *Puma concolor*. It is also known as cougar, puma,

catamount, ghost cat, over seventy other regional names, and the misnomer panther. (The cougar is ironically of the Felinae subfamily, all of which purr, and not Pantherinae, which roar. Black panthers in Africa are black-coated leopards, while black panthers in the Americas are black-coated jaguars, and both are Pantherinae. No black-coated pumas have been verified, leading zoologists to believe such sightings are misidentified.) "Little Dog" is also a Canadian television series, set in Newfoundland and Labrador, which explains the larger number of searches for Little Dog in Maine, the state closest to Newfoundland and Labrador. Interestingly, there mainly seems to be an inverse relationship between the range of coyotes and cougars and the respective searches.

- "Shark attack" vs "childbirth": While both of these things might be considered risky, there is not much of a relationship between them. As might be expected, the "shark attack" search is more common in most coastal states (and, for some reason, West Virginia, Kentucky, Arizona and Nevada, despite being landlocked). Just like Frostbite vs. heat stroke, a tiny part of North Carolina is miscoloured.
- "Snakes" vs "ants" vs "bees" vs "alligators": These are all dangerous animals that cause occasional human fatalities (mainly from allergic reactions for ants and bees). There is no noticeable pattern in which animal is searched most often, though only Florida has alligators as the most common search of the four. Florida presumably has Alligators as the most searched item on



this list as it is where the Everglades are located, a vast area of swamp and marsh that, aside from maintaining the ecosystem and the water supply of Florida, also is home to an obscene number of alligators. This may also be a reference to comic #1845, as Randall yet again chose a map embedding that draws attention to (and arguably makes fun of) Florida. The search volume for bees in Utah may be erroneous because Salt Lake City is home to the minor league baseball team "The Bees" and thus Utah would have a large number of searches looking for the baseball team rather than the animal.

- "Retirement planning" vs "bungee jumping": The implication here is that people in some states are more concerned with short-term fun rather than long-term planning. The contrast is more striking since bungee jumping is a potentially dangerous activity and people practicing it might be seen as likely to die young enough not to need a retirement plan. Bungee jumping is actually a quite safe activity, due to most operators following rigorous safety procedures, but habitual thrill-seekers may then end up putting themselves at greater risks in other ways.
- "Super Bowl" vs "funeral home": This is an attempt to contrast interest in a popular sports (and media) event against a rather somber topic.
- "Resume tips" vs "skateboard tricks": Another comparison between learning a "serious", goal-oriented skill (career advancement) and a "silly", fun skill (skateboarding). It is also an imperfect rhyme. Interestingly, of the states with enough data for a result,

only Arizona had more hits for "skateboard tricks".

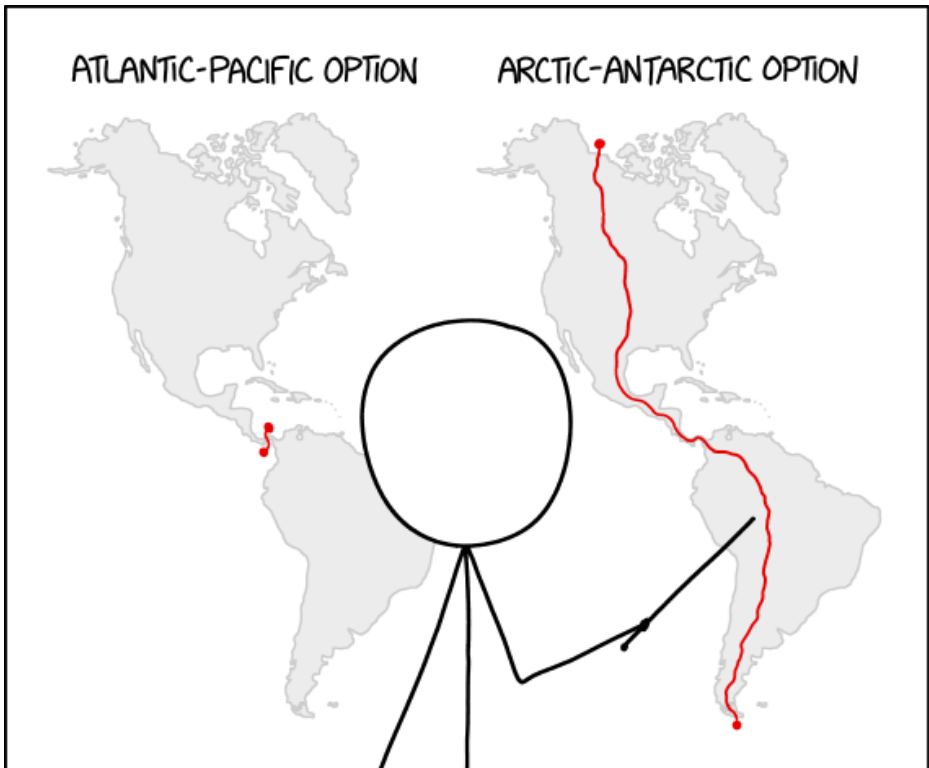
- "Donald Trump" vs "What do I do": The implication here seems to be that people in some states are more likely to ask Google "what do I do?", either in panic or in ignorance, than they are to look up the latest doings of the US President. The split shown is not too different from the actual split between states voting for Donald Trump and for his opponent, Hillary Clinton, with the implication that states that tended to vote against Donald Trump being more likely to search for information about him than resort to the more existential query. This may be regardless of personal ideology, in either case, as both supporters and detractors will have their own reasons to follow their respective state's trend; boiled down to this intentionally simplified view, it leaves the reasoning fully open to individual interpretation.
- "Existential crisis" vs "Marco Rubio": Senator Marco Rubio was a candidate for the Republican presidential nomination in 2016. Everywhere but Alaska, people were more likely to look up his name than to search for "existential crisis". This may be due to cabin fever, which is common in Alaska due to the long, dark winters and frequent isolation.

The title text uses two of these maps to paint a picture of the year 2020 (implying that these search patterns are both meaningful and likely to continue into the future). In this scenario, most of the country continues to read about Marco Rubio (except for Alaskans, still searching for help with their existential crises), and individuals are

trying to learn about etiquette, sexting, or both, depending on their location.

## #2127: Panama Canal

March 22, 2019



I STILL DON'T UNDERSTAND WHY THE PANAMA  
CANAL PLANNERS REJECTED MY PROPOSAL.

Once they selected the other proposal, we could have kept shopping ours around, but we would had to modify it include an aqueduct over their canal, which would be totally unreasonable.

## Explanation

The Panama Canal is, as the name suggests, a canal through the country of Panama. It is important for bridging the Atlantic and Pacific oceans, and is an important trade route. The canal is in Panama because this is the narrowest piece of land for crossing between the two oceans. When the Panama Canal was being proposed, several alternate routes were suggested such as the recently-revived Nicaragua Route.

Cueball says that when the Panama Canal connecting the Caribbean Sea to the Pacific Ocean was being planned, he proposed an alternate route that connects the Arctic Ocean to the Great Southern Ocean. At the time, the northern terminus would have been inaccessible, because the Arctic Ocean was almost completely covered by ice. His suggested route runs somewhat to the east of the continental divide and has a total length of slightly over ten thousand miles, in contrast to the real-life canal which is only fifty miles long. The extra length and more-rugged terrain make his proposal much more difficult to build and maintain than the real-life Panama Canal.[citation needed]

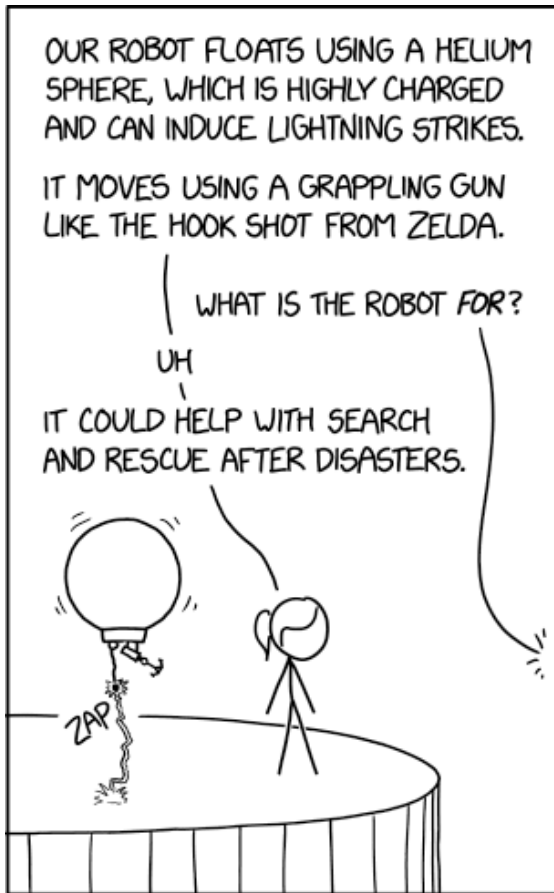
Moreover, while the real-life canal significantly shortens the travel distance between major cities on the east and west coasts of the Americas, his alternative offers little benefit over traveling north or south in either the Atlantic or Pacific oceans. In fact, with the lack of currents that can aid travel and the slow speed required

to traverse canal locks, it would be significantly slower. In addition, ships would have to wait approximately 100 years for global warming to melt the ice in the Arctic Ocean along the northern coast of North America sufficiently for them to enter or exit the northern end of the canal. (However, since construction of this canal might take even longer, the ice might not be a problem by the time it was completed.)

The title text references the now-existing Panama Canal, and the fact that Randall's canal would need to cross it at some point. The title text suggests that crossing two canals would have to be done via aqueduct, instead of the more useful at-grade crossing, most likely at Gatun Lake, which would allow boats to travel between the two canals by simply connecting them. The humor here is that this canal would be one of the most ambitious construction projects in history; an aqueduct being added to the costs is an expense on the same scale of needing an extra screw to hold something in on Apollo 11. The route depicted appears to cross the Mackenzie, Missouri, Rio Grande, and Amazon rivers anyway, so only this additional crossing is apparently "unreasonable."

## #2128: New Robot

March 25, 2019



"IT COULD HELP WITH SEARCH AND RESCUE" IS ENGINEER-SPEAK FOR "WE JUST REALIZED WE NEED A JUSTIFICATION FOR OUR COOL ROBOT."

"Some worry that we'll soon have a surplus of search and rescue robots, compared to the number of actual people in situations requiring search and rescue. That's where our other robot project comes in..."

## Explanation

The comic is a commentary on how many robots and engineering products are labeled as being for “Search and Rescue” purposes.

Search And Rescue (SAR) involves entering an unknown, possibly hazardous disaster-stricken environment, identifying humans or other items of interest which may be hidden, partly (or completely) buried, or injured, and then figuring out how to safely extract the target and deliver it to safety. These tasks are hard enough for humans and are even more challenging for robots, which generally work better in well-controlled situations. This is why many robot challenges are themed around search-and-rescue; the techniques that are developed for handling such challenging circumstances can be applied to make other robots (such as robotic caretakers, autonomous cars, AI-assisted medicine, and other lucrative applications) more robust.

The comic may be remarking that 'search and rescue' may be used as a cover for developing robots that will actually be tasked to 'search and destroy'. (See: lethal autonomous weapons.) Although search-and-rescue is a function that militaries perform, a robot that can satisfactorily perform a search-and-rescue task can easily be adapted to more destructive purposes. Randall has previously written about his concerns about human authorities misusing military robots in 1968: Robot Future.



The joke is that the group of engineers who built the robot did it just because it would be cool to have a robot that can induce lightning strikes and has a grappling gun like the hook shot from (The Legend Of) Zelda. Realizing that they need to have an actual purpose for the robot the engineer presenting the robot makes up the reason that it could be used for search and rescue operations. The grappling gun can be used to pull people out or supply food to people stuck in a place. In the case that there is a dangerous amount of charge present in the atmosphere lightning can be induced which will protect other objects and people from lightning. Also, the helium sphere can allow the balloon to float in places that are hard to reach. (Another possible interpretation is that the question "What is the robot for?" meant why do the helium sphere and grappling gun need to have a robot — and the answer means that the robot is to rescue those who are hit by either the lighting or the grappling gun.)

The Hookshot is a type of grappling hook that is a recurring piece of equipment in The Legend of Zelda video game franchise, first appearing in the 1991 game The Legend of Zelda: A Link to the Past. It is a machine consisting of a chain and hook, which can be used by Link, the protagonist and player character of Zelda. When used, the chain extends and sends the hook attached to it towards its target. If the hook latches onto certain objects, Link reels himself in towards that object. Link can also use it to pull enemies and objects towards him. Although it is referred to by the traditional

'Hookshot' name, the traditional Hookshot involves a bladed tip that mounts in wood; the grappling gun equipped on the robot is more reminiscent of the later Clawshot, which grasps its target on contact.

In theory, the Hookshot-esque function of the robot could be used for anchoring purposes - a useful function for a flying robot in search-and-rescue situations. If it is using a Clawshot design, it could also conceivably seize the parties in need of rescue. However, merely by comparing the grappling device to the Hookshot, it is clear that its attachment was specifically designed in an effort to replicate the game's tool.

The title text ominously suggests that since there are more rescue robots than required for the number of people needing rescue, another robot project will be used to place people in need of rescue, or destroy search-and-rescue robots. (Even more ominously, it is possible that this may be the project that creates a need for rescue, as the fires caused by the lightning strikes could be the disaster from which rescue is needed.)

## #2129: 1921 Fact Checker

*March 27, 2019*

AN INVESTIGATOR CLAIMS TO HAVE DISCOVERED IN SOME DUSTY ARCHIVES THAT BACK IN THE DAYS WHEN THE PILGRIMS LANDED EACH PERSON COMING TO AMERICA FROM ENGLAND WAS REQUIRED TO BRING WITH THEM EIGHT BUSHEL OF CORN MEAL, TWO BUSHEL OF OATMEAL, TWO GALLONS OF VINEGAR, AND A GALLON EACH OF OIL AND BRANDY.

IN VIEW OF THE FACT THAT NOTHING OF IMPORTANCE HINGES ON THE TRUTH OR FALSITY OF THIS STATEMENT, NOT MUCH TIME NEED BE CONSUMED TO ASCERTAIN WHETHER THIS IS TRUTH OR FICTION.

—KANSAS CITY SUN  
FRIDAY, MAY 6<sup>TH</sup>, 1921

I HAVE A GRUDGING RESPECT FOR  
THIS 1921 NEWSPAPER FACT-CHECKER.

POLITIFACT SAYS: MOSTLY WHATEVER

## Explanation

This comic shows a 1921 newspaper article with information about the Pilgrims coming to America. Randall has a 'grudging respect' for the author, who feels the information is so unimportant that no fact-checking has been done, and has enough integrity to inform the reader of this.

The Kansas City Sun referenced by the comic was a newspaper in Kansas City, Kansas that ran from 1892 to 1924(?). (Interestingly, there was also a Kansas City Sun in Kansas City, Missouri that ran from 1908 to 1924.)

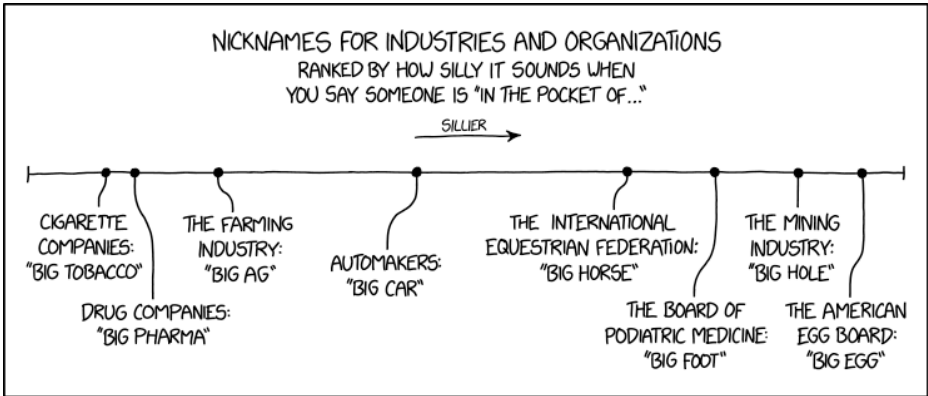
PolitiFact, mentioned in the title text, is a fact-checking project which evaluates the truth or falsity of various statements made by politicians and other people involved in U.S. politics. The positions on its rating scale are "True", "Mostly True", "Half True", "Mostly False", "False", and "Pants on Fire", the last position being reserved for the most egregiously "false" claims. "Mostly Whatever", the rating identified in the title text, is presented by Randall as a rating that could apply to claims that have so little relevance or interest that they are not worth checking. See also 1712: Politifact.

As for the purported fact, a modern summary of the Pilgrims' supplies indicates that the Pilgrims did bring all the listed items of food and drink, though it does not make it clear whether these supplies were required or what quantities were brought. Compare the newspaper

list ('eight bushels of corn meal, two bushels of oatmeal, two gallons of vinegar and a gallon each of oil and brandy') to the list from <http://mayflowerhistory.com/provision-lists> ('Biscuit, beer, salt, (dried) beef, salt pork, oats, peas, wheat, butter, sweet oil, mustard seed, ling or cod fish, "good cheese", vinegar, aqua-vitae, rice, bacon, cider'). Note: 'corn meal' = 'wheat'; 'oatmeal' = 'oats'; 'vinegar' = 'vinegar'; 'oil' = 'sweet oil'; 'brandy' = 'aqua-vitae.'

## #2130: Industry Nicknames

March 29, 2019



As far as "being in the pocket of Big Egg" goes, I think the real threat is Chansey.

## Explanation

"Big industry" is a common nickname used to describe corporate concerns in the United States which have near-monopolistic control over significant areas of the economy, which allow them to wield a large amount of control over markets, as well as influencing political decisions. To be "in someone's pocket" means this entity can readily influence the subject's behavior, whether by bribery, blackmail, legal maneuvering, threats, lobbying, social influence, financial control, or any other means.

Of the 8 industries listed, Big Tobacco and Big Pharma are nicknames that are commonly used. Big Ag is less commonly used, but is increasingly visible, as agriculture is increasingly dominated by large and powerful corporations, rather than individual family farms. While the rest of these names are purely fictional, Randall could be imagining a possible future in which these industries become big players in the political arena. The mining industry may be referred to in this context by sector, as Big Coal or Big Oil (Randall uses the term "big hole", which sounds much sillier. Most, but not all, forms of mining involve large holes.) The U.S. automobile industry was until recent decades referred to as "Detroit," later meaning only the Big Three automobile manufacturers before falling out of common usage. "Big Foot" is likely a reference to the mythical creature Bigfoot. Those who have been on the rough end of how large organizations can push not only individuals but entire communities around in a mafia-like way may take

issue with a medical board being equated with such groups.

Chansey, mentioned in the title text, is a type of female-only Pokémon who carries around an egg in her marsupial-like front pouch. For Chansey the phrase "in the pocket of Big Egg" would be rather literal, except that the egg is in her pocket, rather than the other way around. Randall does not specify why Chansey would be a "threat" or why a Pokémon would be bribing people. Perhaps because, if being in the pocket of Big Egg is bad, and Big Egg is in the pocket of Chansey, then Chansey controls Big Egg and is the one to worry about.



## #2131: Emojidome

*April 01, 2019*



Thank you to the xkcd April 1st volunteers/commentators, including @Chromakode, Kevin, @Aiiiane, Patrick, Kat, Reuven, @cotrone, @bstaffin, @zigdon, schwal, Stereo, and everyone who voted!

## Explanation

This was the ninth April fools' comic released by Randall. The previous fools comic was 1975: Right Click from Sunday April 1, 2018. The next became 2288: Collector's Edition, which was delayed two days and released on Friday April 3, 2020. The interactive comic began at noon ET (16:00 UTC) on April 1, 2019, and ended a day later. In it, users were shown two emojis and voted for their favorite before the time ran out. 512 different emojis were paired against each other in a cup or bracket system, with only one winner. See more below under How it worked.

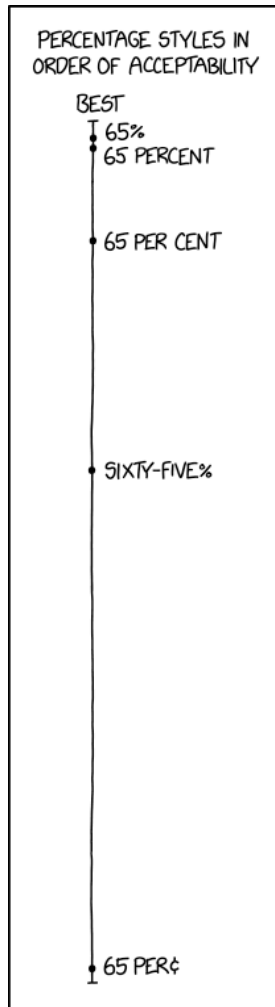
Brackets - like the one in this comic, for finding the best emoji - are a recurring theme in xkcd. It is also relevant for this time of year, and two years ago in 2017, the first comic in April, 1819: Sweet 16 from April 3rd was a bracket, referencing March Madness. The 2019 version of the National Collegiate Athletic Association College basketball national championship tournament began March 19th and ends April 8th 2019. So this comic could also be said to reference this, although it is not so explicit here. Earlier Randall made another large and "silly" bracket in 1529: Bracket (which someone then actually made into an online voting system, just like in this comic).

The title is a reference to the movie Mad Max Beyond Thunderdome, which had the tagline: "Two men enter. One man leaves." The "Thunderdome" in the film is a

gladiatorial arena where conflicts are resolved by a duel to the death. In the final round, the Milky Way emoji (🌌) won against the Hedgehog emoji (🦔). The comic was updated to show the result.

## #2132: Percentage Styles

*April 03, 2019*



In a tribute to classical Latin, I started pronouncing it 'per-kent.' Eventually my friends had to resort to spritzing me with a water bottle like a cat to train me out of it.

## Explanation

On March 29, 2019, The AP Stylebook changed a long-standing rule that forbade press writers from using the percent sign (%) when writing percentages. This had long been a controversial rule, leading to much debate over the preferable way to write percentages, before the Associated Press finally conceded the point.

The comic lists the best to worst ways in which you can write out phrases that are phonetically the same as "65%".

They go from the common "65%" and "65 percent" to "65 per cent," which is not common in Randall's area and time, to the eccentric "sixty-five%" and "65 per¢" (using the cent currency symbol) which are not used in normal writing and would stand out like a sore thumb when read. The middle option, "65 per cent", was common in older literature, along with "65 per cent.", using "cent." as an abbreviation for "centum", which is Latin for "hundred". ("per" in Latin translates to "through", "for", and several other English prepositions.) The entire string would translate to "65 for every hundred." "Per cent" is more widely used in British English than in American English today.

A small gap between the ends of the bar and the best and worst options may suggest the existence of even better and worse options not listed in this comic, such as "6ty5/¢".

Other abbreviations not mentioned in the comic include

"pct.", "pct" or "pc". See Percentage.

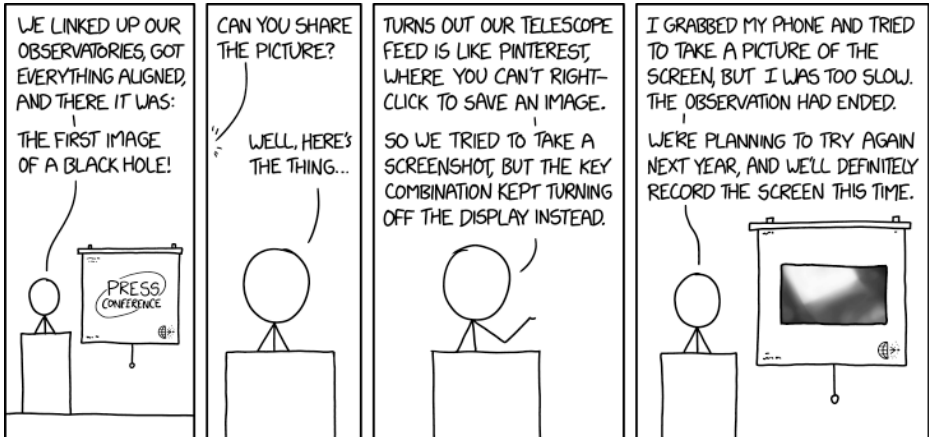
The title text references the ambiguity of hard and soft C in English. In Classical Latin, "C" is always pronounced like "K". However, in English, most "C"s before E, I and Y (including "percent") are soft, and pronounced like "S". In academia, Latin students are taught the Classical Latin pronunciations of words, rather than the pronunciation used by the Catholic church. Some students of Latin may adopt the Latin pronunciation of English words derived from Latin. Such people may tend more to pronounce, even when not the correct choice, "celtic" like "keltic" (this is the correct choice, except for the basketball team), "caesar" like "kaiser", or "cent" like "kent" (although since this involves obviously saying something others aren't going to understand unless they took the same classes, it might as well be "per kentum").

People sometimes train a cat out of a bad behavior, such as scratching upholstery, by spritzing the cat with water when the cat does the undesired behavior. In this case, Randall's friends found him so annoying they trained him out saying "per kent" by spraying him with water every time he pronounced it that way. Training people this way was previously a punchline in 220: Philosophy, while training a cat this way was previously a punchline in 1786: Trash.

**Styles and their acceptability[edit]**

## #2133: EHT Black Hole Picture

*April 05, 2019*



[five years later] Ok, it seems we were accidentally zoomed in slightly too far. But imagine there's a cool-looking twisted accretion disc just outside this black square!

## Explanation

This comic references the Event Horizon Telescope, an international project dedicated to imaging black holes Sagittarius A\* and M87\* with angular resolution comparable in size to their event horizons. The first image of M87 was released to the public on Wednesday, April 10, 2019, five days after this comic's release, and appeared on the same day in the comic 2135: M87 Black Hole Size Comparison.

The image was produced from data gathered since 2006, collected by over a dozen radio telescopes around the world and combined through a process called interferometry. Normally, a telescope's resolution is limited by the size of its aperture, but by recording radio signals at multiple sites, the minute differences between the signals can be digitally processed into an image with much higher resolution. The telescopes used for the EHT are in Hawaii, North and South America, Europe, and Antarctica, and so the effective diameter of the collective EHT is almost the size of the Earth itself. As each telescope recorded observations of the black holes, the results were written to hard drives and mailed to observatories at MIT and the Max Planck Institute for Radio Astronomy for processing. Astronomical recordings can involve astronomical amounts of data, so the raw, original, feed from a telescope may never be stored if it is too dense -- it is instead processed live by computers to capture the information of interest, and the processed result is stored.



The first image released by the EHT was expected to be in April 2017, but unforeseen events delayed it by two years, to April 2019. Randall predicts this trend will continue, and makes a joke by analogy to real-world difficult experiences capturing important moments.

Luckily this comic was not in any way prophetic, and five days after this comic was released the EHT team released a black hole picture for the world to enjoy.

The comic shows Cueball giving a press conference on the recent photographing of a black hole. However, the photograph is a disappointment, caused by the spectacular failure of several systems:

- You cannot download the picture.

Obviously, it would be quite impractical to fail to reliably provide this in an astronomical system. Cueball describes the system as being like Pinterest, where JavaScript prevents you from right-clicking on an image so that you could save it (or at least attempts to, there are many workarounds).

- You cannot screenshot the picture.

Cueball states that they then tried to take a screenshot, but the key combination to make a screenshot instead turned off the monitor where the picture was being displayed whenever they tried to use it, requiring extra time and effort each attempt in order to return to the view of the black hole. This could reference the fact that many mobile devices incorporate the power button in

their screen shot combination and the power button can also turn off the screen. Laptops and operating systems may also have undocumented key combinations that blank the screen, which users can accidentally press when in a hurry and create further stress for themselves. Content under DRM may also prevent screenshots, and attempting to screenshot a protected video will result in a black image.

- The viewing period ends before a physical camera can be used.

As a last act of desperation, Cueball took out his phone and attempted to take a photo of the screen showing the black hole, but by that time, the observation had ended, and the photo was lost.

In reality, none of this should be an issue as the picture would be immediately saved by the system and would not need to be downloaded from the site, but NASA especially knows that developers of a system can never predict the obscure happenstances that can combine to create failure at the end.

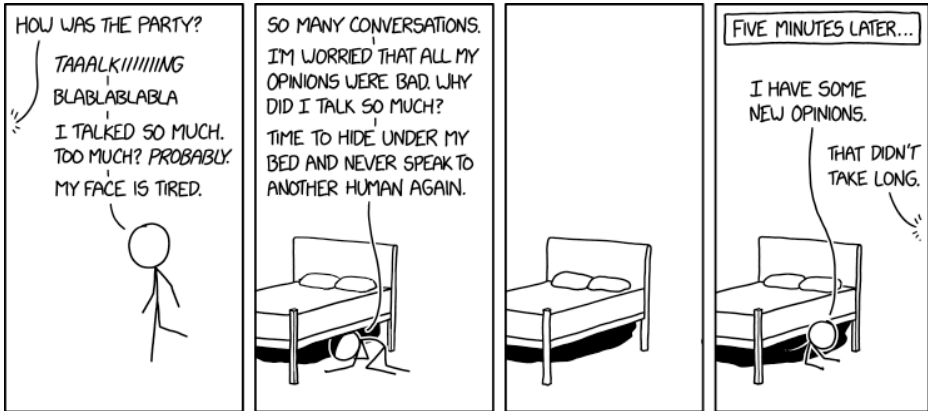
Cueball then states that they would try to take a picture of a black hole again next year.

The title text explains that (after presumably five years of annual tries), the picture failed again as the telescope was too zoomed in and only captured a featureless square. Since a black hole by definition returns no light sent to it, the photograph would be entirely black. Researchers

however are primarily presumably trying to obtain images of the more interesting edge known as an accretion disc, which could actually be meaningfully photographed. The joke is that the black hole could only be photographed once a year, and in each year some incidental set of mistakes combined to prevent the photograph from actually being shared with anybody. This could be a reference to the cosmic censorship hypothesis, which states that a "naked" singularity cannot be viewed from outside an event horizon, where in this case the censor is some kind of "butterfly of doom" that bedevils astronomers who attempt to image one anyway, similar to some interpretations of the Novikov self-consistency principle (a possible resolution to various time travel paradoxes which asserts that any event which would lead to a paradox must have probability zero).

## #2134: Too Much Talking

April 08, 2019



Next time I go, I'm going to prepare a whole bunch of opinions that I'm sure are good, and make everyone sit quietly while I run through them.

## Explanation

Cueball has recently returned from a party, something which is unusual since Cueball has mostly been shown as an introverted type. Like most introverts, social interactions and obligations have worn him out, and different from most after-party regrets, he appears to have "talked too much."

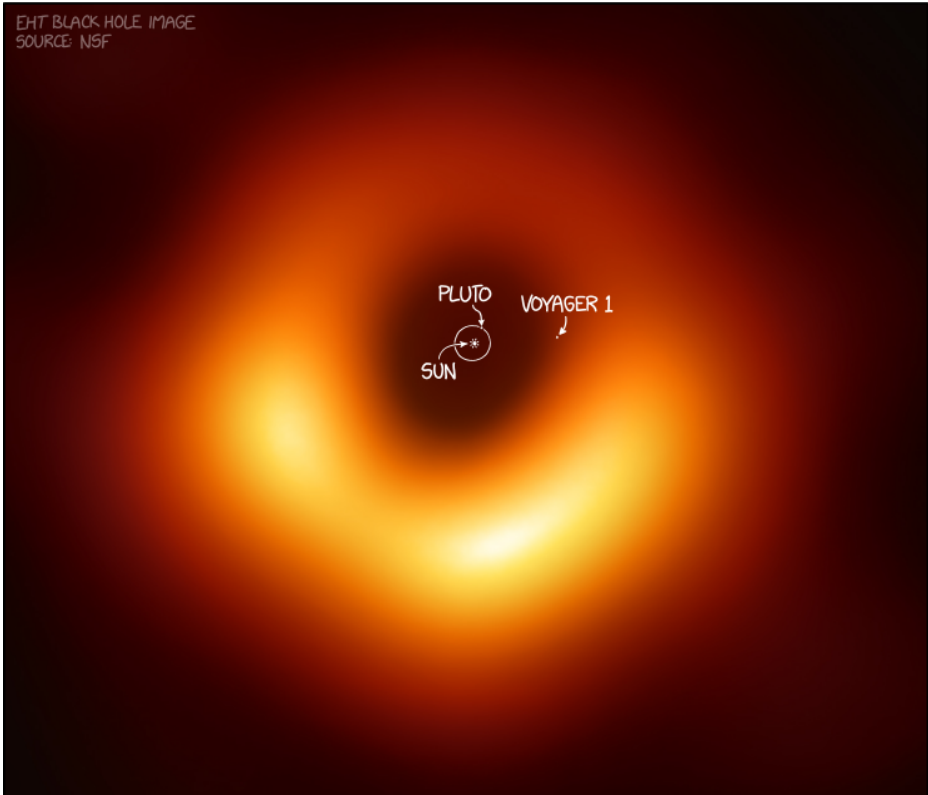
While at the party, he has likely expressed opinions that might be rejected or seen as embarrassing by his social circle or society as a whole, and is now remorseful and embarrassed he said such things. In his shame, he recedes under his bed, but evidently he finds new opinions to feel strongly about, and quickly returns to society.

The title text presents a suggestion that will likely not go over well, as forcing those at a party to quietly listen to you is a great way to kill the party. It also does not allow others to respond to said opinions before moving on to the next.

## #2135: M87 Black Hole Size Comparison

*April 10, 2019*

SIZE COMPARISON:  
THE M87 BLACK HOLE  
AND  
OUR SOLAR SYSTEM



I think Voyager 1 would be just past the event horizon, but slightly less than halfway to the bright ring.

## Explanation

This comic shows the picture of the M87 black hole by the Event Horizon Telescope that was published on the same day as this comic. Overlaid on the picture is a scale image of the Solar System, showing the Sun, Pluto (one of the most well-known dwarf planets) and its orbital path, and Voyager 1, a deep-space probe and the current farthest probe from Earth. The comic is quite similar to 1551: Pluto, in which Randall overlaid annotations onto the recently-released first images of Pluto taken by the New Horizons spacecraft.

The point of the comic is to celebrate the release of this image by the Event Horizon Telescope, referenced two comics earlier, in 2133: EHT Black Hole Picture, as well as to indicate the hugeness of M87 and the awe-inspiring thing that space is. This image has been widely publicized as being the first image ever of a black hole. Science had no visual evidence of black holes at all until 2012.

In the title text Randall hypothesizes that if the Sun were at the center of M87, Voyager would be outside the event horizon. This is confirmed by a 2015 study in which the Schwarzschild radius of M87\* was found to be  $5.9 \times 10^{-4}$  pc, as opposed to the distance of  $7.04 \times 10^{-4}$  pc, at the time the comic was written, between Voyager 1 and the Sun.

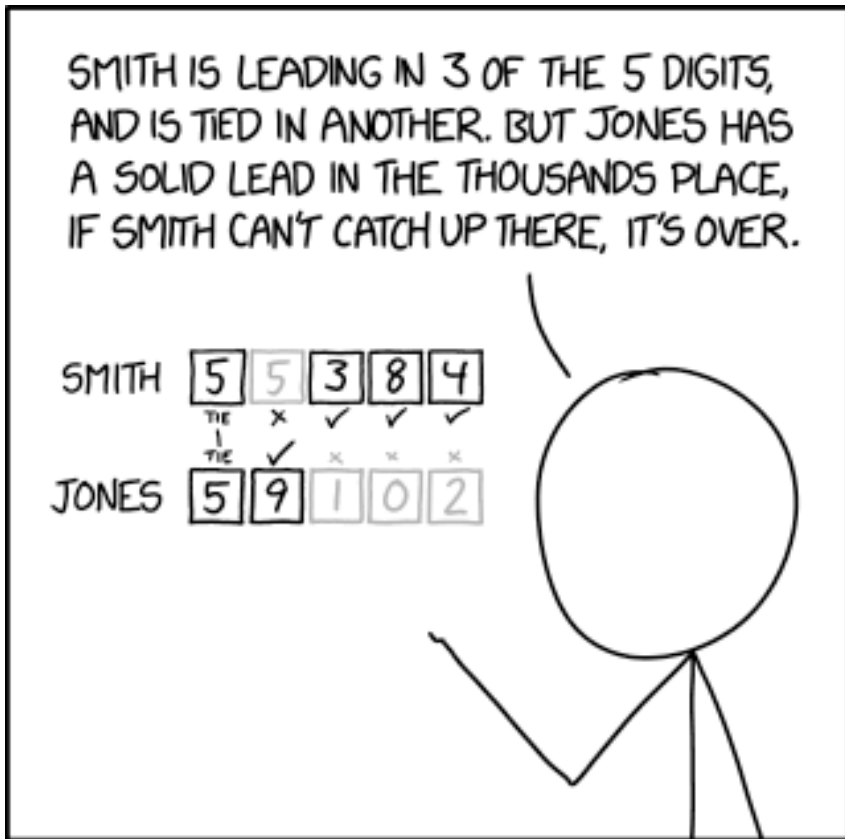
The comic's scale seems to be slightly small; while the

orbit of Pluto should be about 4.9 microarcseconds across, in the comic it's about 3.9 microarcseconds across.



## #2136: Election Commentary

*April 12, 2019*



A LOT OF ELECTION COMMENTARY JUST  
CONSISTS OF UNNECESSARILY CONVOLUTED  
WAYS TO ADD UP WHO HAS MORE VOTES.

This really validates Jones's strategy of getting several thousand more votes than Smith. In retrospect, that was a smart move; those votes were crucial.

## Explanation

This comic is a joke about the way newscasters commentate elections, and how they make it far more complicated than it needs to be in an election in which the candidate with the most votes wins. It's not uncommon for these methods to be used to imply the election is neck-and-neck long past the point one candidate has an insurmountable lead.

Smith has 55384 votes, while Jones has 59102 votes. Instead of comparing the votes as one number, and admitting that Jones' four thousand vote lead is likely going to earn him the win, Cueball compares each digit to see which is larger. Smith's digits in the hundreds, tens, and ones are all higher than Jones', so ultimately he implies that Smith has a chance to win, if only he could pull ahead in the thousands digit and secure a dramatic upset. In reality all that matters is who has the higher total number of votes.

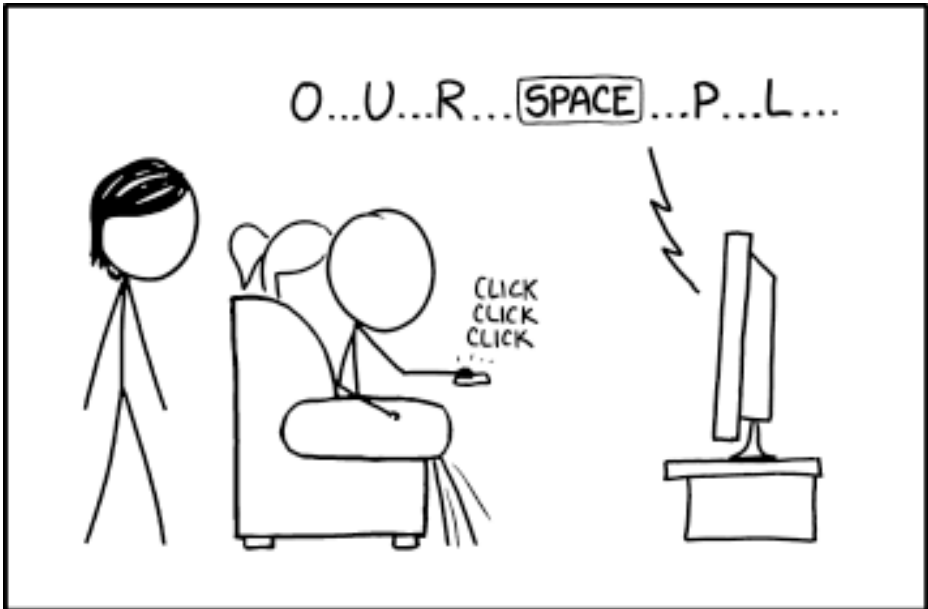
It should be noted that for U.S. Presidential elections, the candidate with more votes does not necessarily win. Each state (plus the District of Columbia) gets a certain number of votes, and the victor in those states usually (though not always) receives all of the state's votes. In that specific case, tracking individual victories (though in states, not in digits) is actually highly relevant to who wins. That said, the comic appears to be depicting something on a much smaller scale, such as a municipal or district election, which is likely to use the more

common most-votes-wins method of election.

The title text is a similarly satirical twist on a common news comment during elections. Candidates often employ different strategies during the election season, with varying degrees of success. For example, if a strategy collected many votes (or important votes, see above paragraph), then it could be said that the area it affected was "crucial". Here, the area affected by Jones' strategy (an entire place value) is said to have been crucial — an obvious claim, seeing as greater place values always result in greater amounts indicated.

## #2137: Text Entry

*April 15, 2019*



THE WEIRDEST THING ABOUT 2019 IS OBVIOUSLY THAT DONALD TRUMP IS PRESIDENT, BUT I THINK THE SECOND WEIRDEST IS THAT YOU SOMETIMES *STILL* HAVE TO TYPE STUFF IN BY PICKING LETTERS ON A SCREEN ONE AT A TIME WITH A CURSOR LIKE YOU'RE ENTERING A HIGH SCORE IN A 1980s ARCADE GAME.

I like to think that somewhere out there, there's someone whose personal quest is lobbying TV providers to add an option to switch their on-screen keyboards to Dvorak.

## Explanation

In this comic, Randall remarks upon something that he considers to be an absurdity of modern living; that in spite of our amazing advances in technology, there still exist user interfaces in 2019 where a person has to "pick letters" to type, a somewhat clunky and inefficient method of text entry. This can be seen when doing searches in a TV guide menu or in menus for streaming options like Netflix or Hulu. Some of these menus may allow for voice searches or support bluetooth keyboards, but the traditional method is still to select letters via a cursor. Many controllers for devices only have a few buttons, which makes it necessary to use schemes such as scrolling around a picture of a keyboard to laboriously select letters, making this extremely inconvenient and annoying to users. The fact that these haven't been replaced with better interfaces comes as a surprise to Randall, hence him believing it to be the second most weird thing in 2019. Cueball is probably looking up *Our Planet* which was a popular Netflix series when this comic was released. Cueball has spelled out "O U R [space] P L" so far.

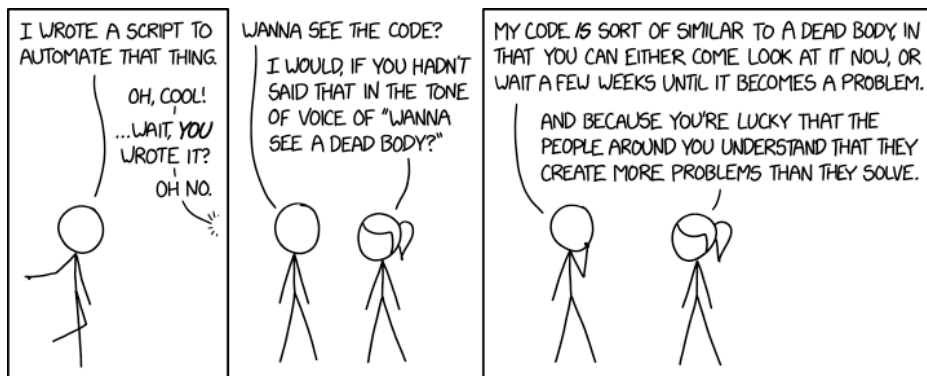
Randall references the "high score" in an arcade game. When achieving a high score in an arcade game, the user typically is able to enter their name or initials into the machine. These are entered by picking letters one by one (and usually under a time limit, for extra fun and/or stress), as the comic mentions.

The title text mentions the keyboard system Dvorak, a recurrent theme on xkcd, which is a keyboard layout patented by August Dvorak and William Dealey. As the Dvorak layout is optimized for more efficient typing with two hands, it is unlikely that using it would be more efficient than a standard Qwerty when limited to cursor entry methods. Another drawback would be that the Dvorak layout is visually unfamiliar to most people, even to many Dvorak typists who rarely look at their keyboard and instead rely on muscle-memory to find keys. As such it could be confusing for users to use for TV selection menus compared to either the more visually familiar Qwerty layout or showing letters in alphabetical order. Alternately, Randall may be referring to Dvorak's placement of frequently used letters clustered in the center as a potential slight improvement over the linear A-Z layout of such interfaces (a half-measure offered ironically, of course).

Although the focus of this comic is on the text entry method, Randall prefaces the comic with what he considers to be the actual weirdest thing about 2019: that Donald Trump is the president of the United States of America. Randall had previously expressed support for Trump's opponent, Hillary Clinton, in the comic 1756: I'm With Her which preceded the 2016 US Presidential Election. In that comic he did not mention Trump.

## #2138: Wanna See the Code?

*April 17, 2019*



And because if you just leave it there, it's going to start contaminating things downstream even if no one touches it directly.

## Explanation

This comic is the fifth and latest comic in the Code Quality series:

- 1513: Code Quality
- 1695: Code Quality 2
- 1833: Code Quality 3
- 1926: Bad Code
- 2138: Wanna See the Code?

Cueball declares that he has written a script to automate some (presumably time-consuming or tedious) task, which pleases Ponytail at first... until she remembers how messy Cueball's code tends to be, and gets worried.

Cueball offers to show her his code, but Ponytail remarks that it sounds like he's creepily inviting her to see a dead body. (This is likely a reference to the movie "Stand By Me," which begins with one of the main characters making this exact offer.) Magnanimously, Cueball accepts the comparison, noting that his code does have at least one similarity to a deceased corpse: although unpleasant, if Ponytail allows it to go unchecked, it causes problems which will get increasingly worse over time. In the "dead body" analogy, a recently-deceased corpse is easier to deal with than one that has been left for a few weeks, which will be decayed, unpleasantly smelly, and will likely have attracted disease-spreading vermin.



Ponytail then makes a near threatening comment where she says that he is lucky that people understand both that his code causes more problems than it solves and that dead bodies create more problems than they solve. Most likely this means that they understand that killing him would cause more problems than it solves (the problem solved would no doubt be his code).

This may be a reference to the concept of technical debt in software development: the idea that an initially poor implementation accrues a sort of "compound interest" over time, becoming increasingly difficult to repair the longer it is left unfixed. This happens because any future development might have to take unorthodox or unrecommended measures to work around the problems that are already there, making the system increasingly complex and fragile the more that is added to it.

In the title text, "downstream" has a double meaning, as it is a term that applies to a situation where a dead body would decompose in or near some river, and as well to a software engineering concept: In the river situation, the dead body will contaminate the water or groundwater that it feeds from and have consequences for organisms that come in contact with that water. In the software engineering analogue, "downstream" refers to software derived from, or depending on, "upstream" software like the cadaver that Cueball devised. The causality with flowing water and software is reasonably comparable: both can be seen as a stream of atoms that are (almost) endlessly divisible and recombining.

## #2139: Email Settings

*April 19, 2019*

EMAIL SETTINGS

DEFAULT REPLY BEHAVIOR

REPLY ☐

REPLY ALL ☐

FORWARD TO ADDRESS BOOK ☒

VACATION AUTORESPONDER

WHILE ON VACATION ☒

ALWAYS ☐

REPLY TO ALL NEWSLETTERS WITH  
"THANK YOU FOR THE NEWSLETTER!" ☒

ATTACHMENT LIMIT

300 KB ☐

1.4 MB ☒

5 MB (BETA) ☐

DEFAULT EMAIL FORMAT

PLAIN TEXT ☒

HTML ☐

CSS ☐

REPLY TO HTML EMAILS WITH "WHOA,  
BUDDY, WHAT'S ALL THIS CODE?" ☒

CHARACTER SET

ASCII (UNICODE 0-127 ONLY) ☐

NON-ASCII (UNICODE 128+ ONLY) ☒

SMART AUTOCOMPLETE

DO NOT SUGGEST REPLIES ☐

SUGGEST REPLIES ☐

AUTOMATICALLY RESPOND TO ALL  
EMAILS WITH SUGGESTED REPLY ☒

IMPORTANT EMAILS

SHOW ☒

HIDE ☐

SHOW UNREAD EMAIL COUNT...

NOW ☒

ON MY PROJECTED  
DAY OF DEATH ☐

SIGNATURE

"THAT'S MY EMAIL. HOPE YOU LIKED IT!" ☒

NONE ☐

What are all these less-than signs? What's an HREF? Look, we know you live in a fancy futuristic tech world, but not all of us have upgraded to the latest from Sun Microsystems.

## Explanation

The comic shows some email settings with a few less-than-helpful options.

- Default Reply Behavior

Normal reply behavior would be to reply to the person who sent the original email. Typically in email programs, there is an option to Reply to all (reply all) other recipients of an email in addition to the sender. Depending on the email usage pattern this is a potentially useful or a potentially annoying option. "Forward to address book" takes this one step further by sending your reply to every person who is in your address book, whether they received the original email or not. This could be a reference to "chain emails", which are popularly forwarded to many users.

- Vacation Autoresponder

This is a message that is automatically sent out in reply to an email to let them know that you are away and won't be replying until you return. Rather than the settings being "on" and "off", this system consists of "while on vacation" and "always". Email systems typically have no way of knowing that you're on vacation (although some email providers, such as Gmail, could figure out if you're on vacation using information gleaned from your emails, such as hotel and flight confirmations). The "reply to all emails with vacation notice, even when I'm not on vacation" is an option used by some companies (e.g.

travel agencies) to let the sender of a request know the expected reply timeline and similar information. In the second case, the notice is not a "vacation notice", but applies the same functionality of the email program.

- Reply to all newsletters with "Thank you for the newsletter!"

This option is completely unnecessary, in that newsletters are usually automated and shotgunned out to thousands of addresses at once, often with a do-not-reply address. Clues such as those aside, this also somewhat presumes that the system can reliably identify all (and only all) the messages that are indeed newsletters.

- Attachment limit

These attachment limits are all pretty small, with 300 kilobytes and 1.4 megabytes being the capacity of old 5.25" and 3.5" floppy disks, and 5 megabytes, while better, is smaller than most high-resolution cell phone camera pictures. It being in beta means that it might not be as dependable. However, setting the maximum attachment size would likely not be a user setting; it would be a setting the email system enforces on the user. In the past with slow connections and very limited mailbox sizes, this option was useful to keep the message size in check. Presently, Gmail still has the same 25MB attachment limit it had in 2004.

- Default email format:
- Reply to HTML emails with "Whoa, buddy, what's all

this code?"

HTML email is a format for sending email with rich-text contents, which may include images and links. If your email client isn't configured for HTML, the content may look like text interspersed with a bunch of weird code. Since HTML email is a common format, replying this way to every HTML email you receive can be an effective way to annoy people. This may be a "throwback" option: a few years ago, email systems didn't always recognize HTML emails, so if you sent an HTML email you might very well receive this kind of reply.

- Character set

ASCII is the character group containing all of the letters in the English alphabet, as well as the digits and common symbols. The Non-ASCII set contains all of the non-English alphabets and the rest of the (lesser-used) symbols. Some of those characters, such as those from Cyrillic and Greek, resemble letters from the Latin alphabet; when spammers use these resemblances to deceive users, it is called an IDN homograph attack, but now that this email client is set to exclude ASCII characters, the user must use the same technique to communicate with speakers of most European languages.

Older computer programs often only allowed ASCII characters or a much more limited set of characters than the full amount of recognized Unicode characters, and the email protocol itself requires a form of encoding (often MIME, these days) to send 8-or-more-bit characters via systems designed for the 7-bit

transportation that covers the ASCII set and allowed non-printable characters. It would be unusual today for an email program to default to only allow for ASCII characters to be read or written, although someone might want to deliberately set things that way. The second option is nonsense because, while you would likely want to allow other characters, you would definitely not want to allow only those and exclude the ASCII characters (so people couldn't use regular letters or numbers or the most common punctuation, although most East Asian users can use the Fullwidth form of Latin letters instead).

- Smart autocomplete

Some email platforms, including Gmail, have the ability to use machine learning to suggest possible, usually short reply options for you to choose from. If the original email asks if you want to go to dinner, the auto-complete replies might be, "Yes", "No", "How about Friday?" and then you could choose one, or type your own reply. The third option to automatically respond to all emails with suggested replies is putting a lot of faith in the computer and is likely to backfire quickly, even more so if your recipients also have activated this option.

- Important emails

Showing important emails is the expected behavior, and hiding only them would be a very strange thing to want to do. If it is set to hide only certain emails, a program would definitely do the opposite, and hide emails judged to be most likely unimportant "spam" emails.

- Show unread email count...

Seeing your unread email count is normal behavior, and a good way to see how much you're getting spammed by useless emails from people you never asked for. A projected unread email count based on when the system expects you to die, and how well you do at reading your email on a day to day basis is probably going to be depressing or in the extreme could be so overwhelming to be the actual cause of death on the projected date. Showing the unread email count on the user's projected day of death could also be a reference to a feature in many video games where the player's score is shown when they die. In this case, the "score" would be the user's unread email count.

- Signature

An email signature is a bit of canned text that gets added to the end of an email, often containing your name, and sometimes a bit of other information like a title and other contact information. Having the choices being None and "That's my email. Hope you liked it!" is less useful. Less useful signatures somewhat came into vogue after Apple used it for cheap iPhone advertisement ("Sent from my iPhone") and Apple as well as non-Apple users made fun by using quite creative signatures themselves (here is a breakdown with examples). For many, the actual purpose of email signatures got lost.

- Title text

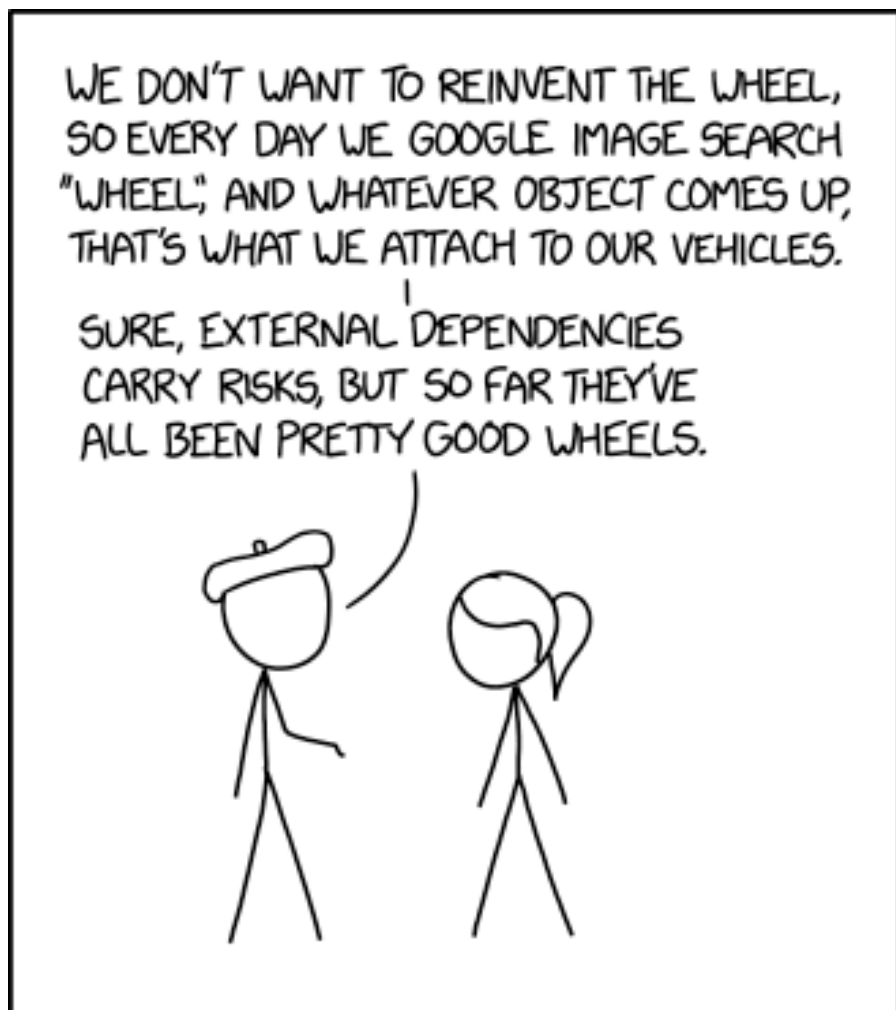
The title text also references HTML email, in which

angle brackets (i.e, less-than and greater-than symbols) are used to show the opening and closing tags of elements. "href" is a common attribute in HTML elements denoting the location a hyperlink will take you to upon being clicked. This is likely another "throwback" reference as Sun Microsystems was a maker of Unix workstations popular in the late 1980s through 2000s (now part of Oracle Corporation). The message could also be written by someone receiving an HTML email that is not recognized as one and directly shown on the screen.



## #2140: Reinvent the Wheel

*April 22, 2019*



Right now it's a bicycle wheel, so we've had to move to lighter vehicles, but the reduced overhead is worth it. There was one week when a wheel of cheese got dangerously close to the first page, though.

## Explanation

"Reinventing the wheel" is an idiom/metaphor that refers to duplicate effort to recreate something that has already been created or perfected previously without adding any value in the process. The phrase relates to the idea that the round wheel was invented a long time ago and there is no way to make it better, as a circle is the most optimal shape. While the phrase includes the word "wheel", it isn't typically directly associated with the wheel but instead uses the word "wheel" because of the easily understandable meaning.

In this comic, Beret Guy works for a company (or this is his own company) that produces vehicles, and he is explaining to Ponytail their decision to not reinvent the wheel for their products, using the phrase in a literal sense instead of figuratively. Instead of determining for themselves what wheel to use, they want to use whichever wheel is presumably considered the "best" wheel by the world, using a daily Google image search for "wheel" to determine the highest ranked wheel, and then using that wheel on the vehicles they produce that day. In reality, this would be a very bad way of choosing the wheels of the automobiles Beret Guy's company produces. In addition to being extremely inefficient, as they might have to change the wheels they use every day, it may also result in copyrights and lawsuits against his company.

The point of the comic is to make fun of programmers or

engineers in general who take the idea that you should never reinvent the wheel too seriously. When these people have a problem, they may Google to find a solution to that problem, and when they find a piece of online code, they use it in their own code, even if it wasn't initially designed to handle the task for which it is being used and thus may have unintended side effects or other issues.

Another way that programmers may go too far in avoiding reinventing the wheel is in using external dependencies. It can be valuable to use external libraries, especially for applications where certain tasks have strange edge cases that a 'reinvention' is likely to miss or require lots of development effort to correctly implement (like time). However, using someone else's code means taking on the risk of security vulnerabilities, and when the library is updated on live installations, the user also takes on the risk that the library might become unavailable or otherwise break. In this case, Beret Guy's company updates their wheel "library" on a daily basis from Google's image search. Google is unlikely to shut down a core search product, but they might change the API that Beret Guy's company uses (unless he's just going to their website himself), and they have been known to shut down projects that people like, such as Google Reader. On the day this comic was released, Randall changed the Header text of xkcd, adding a reference to Google Reader.

The popular programming language Python manages external dependencies with packages called "wheels"

which are "published to the cheese shop", which may or may not be an intended reference.

In any event, Beret Guy is in effect reinventing the wheel by doing a new search for wheels on Google Images every day. If the wheel he finds on Google Images on a given day is suitable for his company's needs, the company would likely be better off using the same wheel on succeeding days (unless circumstances change which make that unfeasible), compared to trying to doing a new search for wheels every day. In addition, Beret Guy's company might be forced to create new wheel-producing machinery every day, although if Beret Guy can transmit soup and air through electrical cords, it may simply be a matter of copying the image then pasting it in real life.

The title text indicates that Beret Guy is currently using bicycle wheels for his vehicles, requiring his vehicles to be lighter as bicycle wheels cannot carry a lot of weight. He says this "reduce[s] overhead", which is both literally true, that his vehicle weighs less, and refers to the usual figurative desire of reducing overhead costs of development by using external libraries. If the former interpretation is correct, this raises the question of why Beret Guy's company didn't try to lighten the load of its vehicles beforehand. Finally, the narrator (supposedly Beret Guy) explains that at one point a wheel of cheese was near the top of the Google images search. If it had reached the top, it would have been disastrous as a wheel of cheese is completely unsuited for use as a vehicle's wheel.[citation needed] Beret Guy implies that his company would have used it if it reached the first

position even though he knows that it would be unsuitable for usage in vehicles, further demonstrating Beret Guy's lack of business knowledge.

On the day the comic was released a bicycle wheel came up first when searching for "wheel", see image in the Trivia section below.

## #2141: UI vs UX

April 24, 2019

<u>DESIGNER</u>	<u>WHAT THEY ARE RESPONSIBLE FOR</u>
UI	ELEMENTS OF THE INTERFACE THAT THE USER ENCOUNTERS
UX	THE USER'S EXPERIENCE OF USING THE INTERFACE TO ACHIEVE GOALS
UZ	THE PSYCHOLOGICAL ROOTS OF THE USER'S MOTIVATION FOR SEEKING OUT THE INTERACTION
U∞	THE USER'S SELF-ACTUALIZATION
UΩ	THE ARC OF THE USER'S LIFE
U∞	LIFE'S EXPERIENCE OF TIME
U●	THE ARC OF THE MORAL UNIVERSE

U[unprintable glyph]: The elements a higher power uses to bend that moral arc. U[even more unprintable glyph]: The higher power's overall experience bending that moral arc.

## Explanation

UI vs UX is a discussion in software engineering of the differences between user interface design (UI) and user experience design (UX). As explained in the comic, UI design is typically concerned with the elements of the interface that a user encounters, while UX design is more concerned about the user's overall experience in using such interface. UX design can be seen as more holistic & abstract than UI. This comic extends the idea, adding increasingly all-encompassing, abstract & fanciful design perspectives.

To start, the two real categories are:

The comic takes this to absurd levels by adding these additional categories:

The title text refers to a higher power bending the moral arc, but mirrors the UI and UX categories, with the implication that the list continues in a spiral through ever more rarefied levels of higher powers, with even less likely symbols denoting them.

## #2142: Dangerous Fields

*April 26, 2019*



Eventually, every epidemiologist becomes another statistic, a dedication to record-keeping which their colleagues sincerely appreciate.



## Explanation

This is a graph of fields of study, ordered by how likely one is to die because of something that that field studies, with mathematics being the least dangerous and gerontology being the most. Gerontology, the scientific study of old age, is shown as much more dangerous than the other fields, so it is far on the right side of the graph. The joke is in exploring what the words "risk" and "danger" really mean in this context — studying volcanoes is likely to put you in dangerous environments, and the volcanologist can be said to have "survived" if they later die of old age. Conversely, studying aging doesn't put you at more risk of aging than the general population, but there is no "surviving" from this perspective, only the chance of dying early from something else.

## Fields[edit]

- Mathematics is such a pure non-physical field that the probability of it being the direct cause of death is extremely low. The study of it might cause death through workplace disputes or absent-mindedly wandering in front of traffic while pondering (as in 356: Nerd Sniping). Famously (though likely apocryphally) Hippasus was thrown overboard a ship by Pythagoras for demonstrating irrational numbers. Archimedes was killed for not following an invading soldier's command because he was wrapped up in his own thoughts trying to solve a geometry problem.
- Astronomy, the study of stars and space. Astronomy is slightly

more dangerous than mathematics, though, since it studies physical objects instead of abstract concepts. In addition to meteor or asteroid impacts, astronomical phenomena that might cause death include solar flares, nearby supernovae, distant magnetar quakes, a solar nova (the likelihood of which will increase over the next billion-odd years), perturbations in earth's orbit, increased or decreased solar radiation, and alien invasion. Given that the density of magnetars and potentially hostile alien civilizations in the stellar neighborhood is completely unknown, and not all past mass extinctions are explained, this one might be misplaced a bit. Although these are all rare events, just one could kill all living and potential future astronomers. That non-astronomers would also be affected seems poor consolation. While astronomers do not study aliens, as such—that would be exobiology—some have sought evidence of alien activity.

- Economics is the study of markets. Markets can kill you by depriving you of goods and services you need to survive. Goods can become unavailable (e.g., cartels, embargos) or unaffordable (through job loss, inflation), in depressions or recessions. The study of such markets usually does not involve great risk, unless the markets are illegal (e.g., illicit drug markets), the economy being studied has put people under great stress, or one's findings are really unpopular.
- Law in this context refers to the rules people have to follow in society, and given the nature of laws (civil and criminal), the odds that your death is related to law is usually low. Possible causes of death more-or-less directly related would include prosecution for a capital crime, persecution under legal authority (such as being killed by an officer of the law), attack

by a guard, or for lack of medical treatment, while incarcerated, or death by exposure after expulsion from one's repossessed or otherwise legally confiscated home. However, when large groups of people are dispossessed, or have the protection of law removed, casualties can be quite high. For instance, the Partition of India in 1947 resulted in 200,000 to 2 million deaths. The laws of the Great Leap Forward contributed to the starvation of tens of millions of Chinese, disproportionately many of them lawyers and law professors. Perhaps most ironically, a lawyer who committed a capital crime in a country that practices capital punishment (such as the United States, China, or Iran), and was executed for it would be directly killed by the thing they study. In 2000, approximately 300,000 died from war and collective violence.

- Criminology is very similar to law, but is the study of crime, meaning it's more dangerous than just "law." Criminologists may be directly involved with criminals in the course of their studies, increasing their exposure to potentially life-threatening behavior. There were 520,000 deaths from violence (excluding war, suicide, and accidental or incidental deaths resulting from criminal activity) in 2000.
- Meteorology is the study of weather. Encountering powerful weather events such as hurricanes, tornadoes, blizzards, floods, and thunderstorms brings the distinct possibility of injury and death. Curiosity to see a storm in person, or (if working for television news) exposing yourself to the weather event in order to file a report, may expose you to lightning, wind-blown projectiles, cold, water, etc., any of which can negatively affect your survival. Less dramatic weather also kills — hot weather can lead to heatstroke and dehydration. Adverse weather events

kill about 100,000 to 200,000 annually.

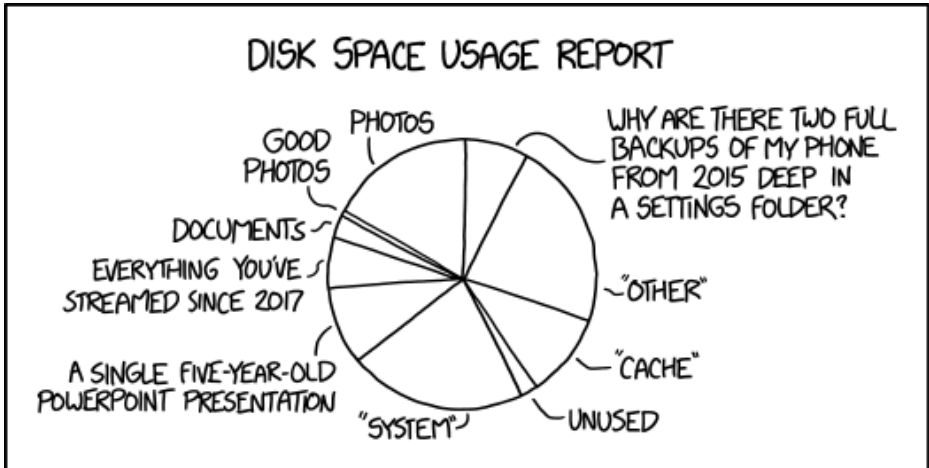
- Chemistry is the study of chemicals and reactions of those chemicals. Since, under terrestrial conditions, everything is made up of chemicals (and chemists often use especially reactive or dangerous chemicals), the likelihood of a chemist's death being caused by chemistry (e.g., explosions, poisoning, chemical burns, suffocation) is not insignificant. Unintentional poisoning is identified as the cause of death for about 200,000 people a year, chemical assisted suicide kills over 300,000 yearly. Many other causes of death, such as snakebite (100,000), drug and alcohol disorders, some respiratory disorders, and cancers are more or less directly caused by chemicals.
- Marine biology is the study of ocean life. Many marine creatures are venomous, many are very large. Death could result from storms, boat accidents, drowning, diving accidents, exposure to pathogenic bacteria, toxins (such as those produced by cone snails, and "red tide" dinoflagellates), allergies to shellfish, or water pollution, in addition to such perhaps more obvious (but overwhelmingly rarer) risks as shark attacks. About 360,000 people die of drowning annually. Unprovoked shark attacks kill an average of 6 people annually.
- Volcanology involves the study of volcanoes, lava, and magma, with obvious risks to the scientists studying them in the field. Volcanoes have killed an estimated average of 500 people per year; most deaths result from remote effects, such as tsunamis and climate disruption. At least 67 scientists have been killed in volcanic eruptions, as of 2017.
- Gerontology involves the study of aging, and of growing old in general. As (to general knowledge) everyone has to this point been observed to age and eventually die,[citation needed] those

who study gerontology are not immune to dying of old age even if they evade all the other possible causes of death — thus making it the most likely among all shown fields. A gerontologist still can die from something else first, but without the inherent risk factors of other professions such as active volcanoes or underwater diving, they're more likely to survive to retirement and thus meet their death of old age.

The title text is about Epidemiology, the study of health and disease conditions in populations. In the event of an epidemic, there is a strong chance that epidemiologists in the search for the cause, transmission, and treatment will be exposed and become victims of the disease in their own right. However, the title text refers more broadly to the role of epidemiology in maintaining detailed statistical records of diseases and other causes of death, such that eventually any epidemiologist (whatever the cause of death) will become one of their own statistics.

## #2143: Disk Usage

*April 29, 2019*



Menu -> Manage -> [Optimize space usage, Encrypt disk usage report, Convert photos to text-only, Delete temporary files, Delete permanent files, Delete all files currently in use, Optimize menu options, Download cloud, Optimize cloud, Upload unused space to cloud]

## Explanation

Many personal computers provide a way to obtain a graphical breakdown of how their storage space is being used, most commonly by representing the filesystem as a pie chart in which each slice represents the proportion of the total storage space being taken up by a particular item.

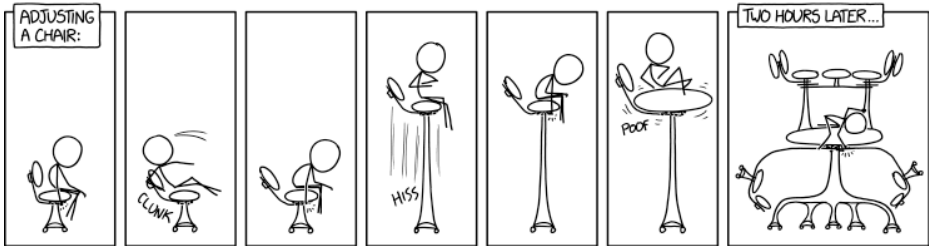
In this comic, Randall has illustrated the usage of his hard disk drive in just such a way, although as is common for him, the items in his hard drive start off seemingly normal and become increasingly strange:

Alarmingly, the "Unused" portion of the pie chart is extremely small, which means the disk is nearly full with very little remaining capacity. Users don't usually worry about what is using space on their computer disk until they get an alert about the disk running out of space - this is likely when a user would resort to viewing this type of graph to figure out what they can delete to free up disk space.

The title text references the management UI of a hypothetical disk cleaning utility. The following options are mentioned in its menu:

## #2144: Adjusting a Chair

May 01, 2019



When I was looking at the box, I should have thought more about what "360 degrees of freedom" meant.



## Explanation

This comic shows Cueball's attempts to adjust a swiveling chair. This comically culminates in a massive chair with a big central seat and several other chairs branching off of it as Cueball continues learning how to adjust it. The chair also apparently has so many controls it takes two hours to discover them all (although Cueball may have shown off his newly-discovered abilities in the mean time, so it might not take two hours of continuous experimentation).

As many people have experienced, these chairs can be quite difficult to raise, lower, or maneuver if one does not know how. Typically, the chairs have multiple knobs and levers underneath the seat, which requires the user to rely on muscle memory to find them, since these levers are commonly used while sitting in the chair. There are often several ways to manipulate each control (may be rotated, moved laterally, vertically, or axially.) One usually needs to experiment with the levers and knobs in a new chair to understand how to work the chair, and it appears Cueball is experimenting with them.

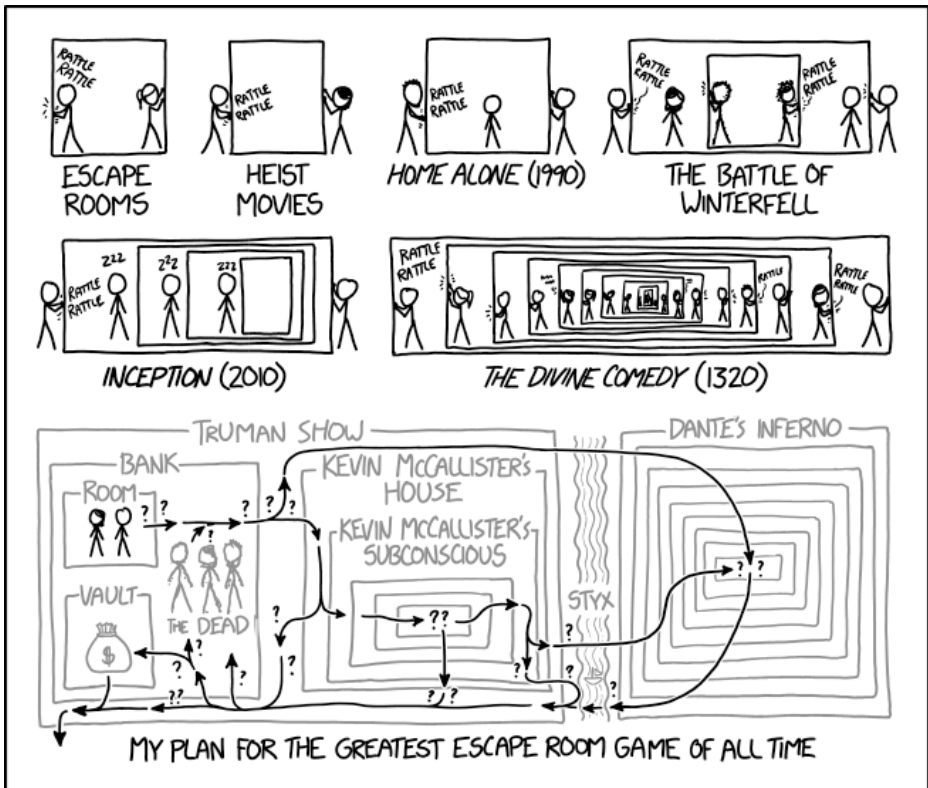
Each step gets farther away from what real-life office chairs could do. In sequence, Cueball finds his chair doing more and more surprising things:

The title text refers to a common claim on such chairs, that the chair offers 360 degrees rotation and several degrees of freedom. This is a double entendre, depending

on if "360 degrees" or "degrees of freedom" is interpreted as an object. However, here it means there are 360 mechanical degrees of freedom, which is the number of independent parameters that define the configuration of an object; in other words, the chair has 360 different levers and options, far more than a standard chair[citation needed].

## #2145: Heists And Escapes

May 03, 2019



The interactive experience is built on a single theological framework that unites Dante, George R. R. Martin, every major heist movie, and Erin Gloria Ryan's "Kevin is dead" Home Alone theory.

## Explanation

The top six panels show a stylized version of various options where people try to get into or out of rooms. There are always two xkcd figures trying to get into or out of a room. One is always rattling, possibly at a locked door. While no door is drawn, the position of their hands indicates this. The second figure always has their hands at head height, possibly looking for weaknesses in the structure. The characters in each panel vary and there seems to be no specific pattern to them.

The six top panels show these scenarios:

- **Escape Rooms:** An escape room is a type of puzzle/adventure game where people are locked in a room, or set of rooms, (discounting emergency exits) and have a certain amount of time to solve the puzzles and leave.
- **Heist movies:** In heist movies, the thieves are trying to get in to a room, usually to steal what's inside.
- **Home Alone (1990):** This refers to the first movie in a franchise, where the home that the burglars tried to rob was protected by someone from the inside, Kevin McCallister (also mentioned in the title text).
- **The Battle of Winterfell:** This refers to the 3rd episode of the 8th season of Game of Thrones, aired five days before the publication of this comic. Here the army of the dead tried to enter the castle of Winterfell (the outer room in the picture). At the same time the dead who

are in the crypt (the inner room in the picture) tried to get out. The living people in the castle were trapped between them.

- Inception (2010): In the movie Inception the protagonists could enter the dream world of others, and while in those dreams they could enter the dreams of someone inside the dream. Inception can be categorized as a "heist" movie, as the main characters are thieves who steal information from their victim's subconscious or plant ideas into it.
- The Divine Comedy (1320): This refers to Dante's work - in particular its first part Inferno, which depicts Hell as nine concentric circles. Purgatory and paradise are similarly concentric, but they are not likely to need to be escaped. Humor is provided by the style of the work's description, likening The Divine Comedy to a movie, though there were no movies in 1320.[citation needed]

At the end, Randall proposes a combination of all of these things, and also combining it with others, to form the "greatest escape room game of all time":

The escape room begins in a small room, shown with Cueball and Megan standing inside, who likely represent the participants of the escape room. An arrow leads out from that room into a larger bank, where some more characters labeled The Dead, referencing The Battle of Winterfell, are standing. An arrow leaves from them that merges into Cueball and Megan's, implying they join them as they escape the room.

The arrows continue outside the bank, into a larger room labeled Truman Show, inspired by the film where the protagonist was living in a constructed reality show, although he did not know it. The path branches upwards around or into Kevin McCallister's house, with the arrows inside spitting yet again, either exiting the house again or entering Kevin McCallister's subconscious, a reference to the movie Inception. The arrows once again split and continue either downwards or to the right, both exiting McCallister's house.

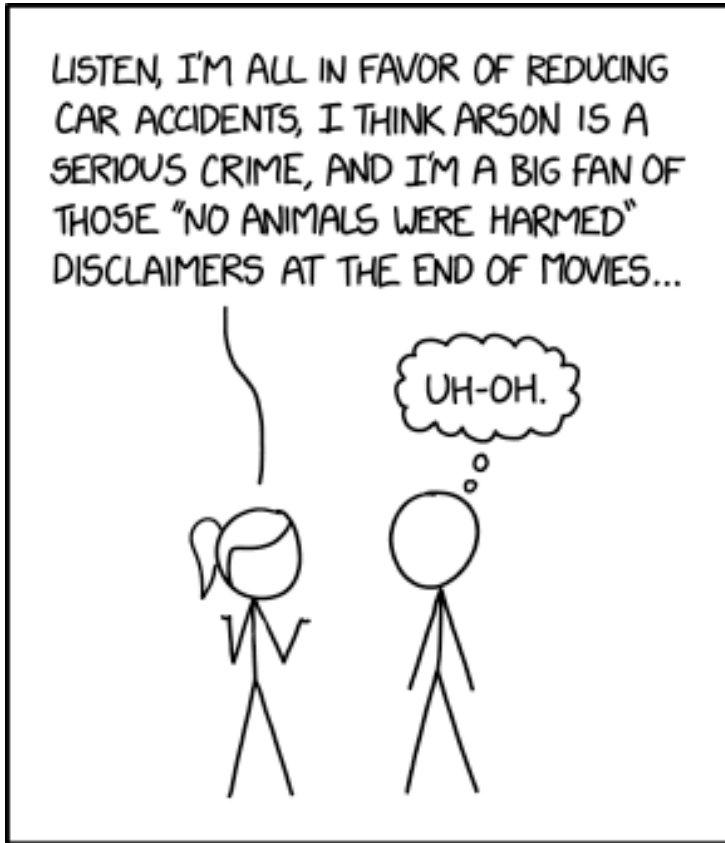
The path to the right splits, the top path crossing Styx, a river in Greek mythology that forms the boundary between Earth and the Underworld, represented by Dante's Inferno, taken from The Divine Comedy, and the other returning to the line that leads downwards. The line that leads to Dante's Inferno is met by the line that leads around Kevin McCallister's house. It can be assumed that this is not a breaking into the underworld as portrayed in some movies, but due to the simplicity of the paths (note that unlike for the escape the line just crosses Styx) it is the possibility of failing prior puzzles and dying. In that case the escape room puzzle would continue with escaping from the underworld to rejoin the puzzles.

Both paths lead downwards back across Styx, rejoining the other lines below McCallister's house. The lines continue to the bank and spit to either re-enter the bank or exit the escape room entirely. The line that re-enters the bank either returns to The Dead or into the bank's vault, which the line also exits the escape room.

The title text refers to this article, which claims that Kevin McCallister is dead, and is actually a ghost.

## #2146: Waiting for the But

May 06, 2019



THE LONGER YOU HAVE TO WAIT FOR  
THE "BUT," THE WORSE WHATEVER  
COMES AFTER IT IS GOING TO BE.

Listen, I'm not a fan of the Spanish Inquisition OR  
predatory multi-level marketing schemes...



## Explanation

Often arguments are made in the form of "I think X, but Y", where Y is almost but not quite contradictory to X. More specifically, the argument would go "I am not [something generally considered distasteful], but [a more specific statement most people consider part of that general statement]". The first part of such a statement can sometimes be viewed as an apology or an excuse because the person talking knows that the second part might upset people. A common example would be "I'm not a racist, but I don't think we should let refugees from Africa into Europe." The idea of denying help to people from Africa will be seen as racist by many people, so the speaker tries to preempt that opinion of themselves.

In this comic, Cueball is having a conversation with Ponytail, who lists several seemingly unrelated but agreeable positions, such as reducing car accidents, treating arson as a serious crime, and approving of "No Animals were Harmed" disclaimers in modern media, with Cueball wondering when the "but.." of the statement will come, and conjuring increasingly outrageous images of what Ponytail could have in mind that involves violating all of them, for example some sort of reckless fiery car stunt involving animals.

Notably, the "and" normally serves as an earlier indicator that a list is coming to the end, as it always comes right before the final entry. Perhaps, Cueball seems to have missed this, hence the continued apprehension. But

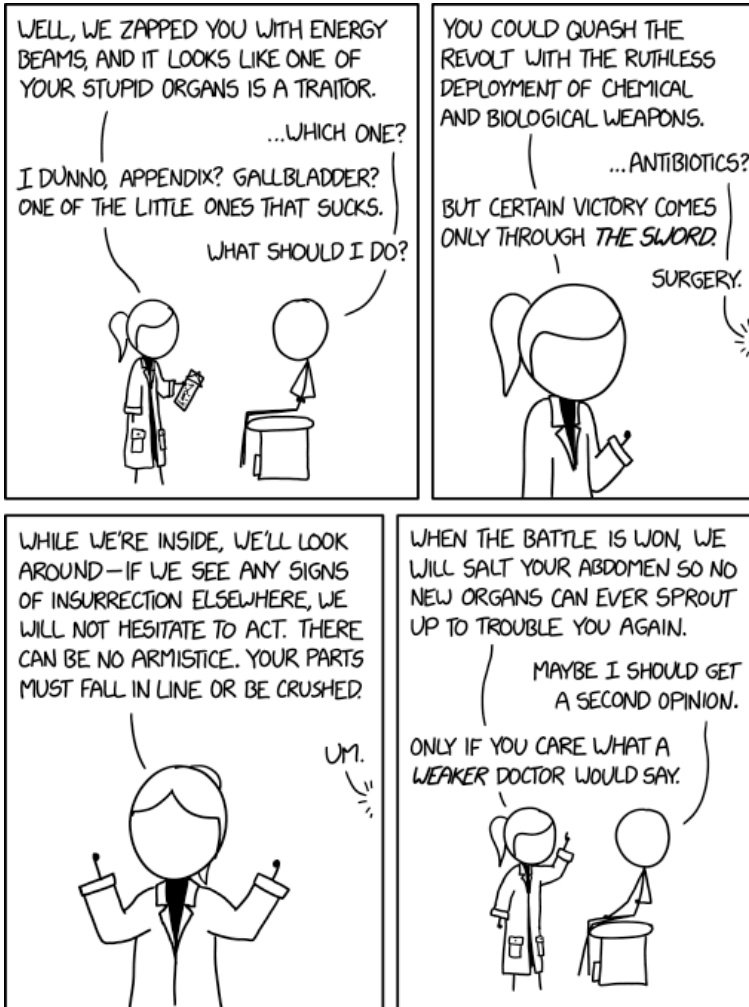
being immediately proceeded by a comma indicates either it is a coordinating sub-clause or, perhaps, an Oxford comma. (Although it seems unlikely that it is the latter, as it is most often applied to a string of more than three items being grouped, and is often considered more confusing than the situation it is supposed to grammatically clarify.)

The title text gives another example of a sentence that will probably be followed by a "but". Multi-level marketing schemes and the Spanish Inquisition are both considered bad in very different ways, so the implication that if the speaker has to apologize in advance for sounding like defending both of them, they must have a remarkably troubling idea in mind, involving somehow using a version of the Spanish Inquisition as an MLM scheme.

Another possible explanation would be that when people hear a sentence that starts with "Listen, I'm" they tend to wait for the "but", and the longer it takes the more tension it may cause them, while the speaker may never intend to say "but". Similar ideas were used for 365: Slides, 559: No Pun Intended and 2032: Word Puzzles.

## #2147: Appendicitis

May 08, 2019



Fortunately, after a brief skirmish, I seem to have gained the upper hand in the battle against my internal organs, at least until they learn to read and find out the mean stuff I've said about them.

## Explanation

Cueball, representing Randall, is visiting Doctor Ponytail, this time to diagnose some medical condition. From her description, zapped you with energy beams, it sounds like they just took an x-ray image, maybe in the form of a CT scan, and Ponytail is following up on the results. It appears that he may have appendicitis, the title of the comic, which could be treated through antibiotics, or through an appendectomy surgery.

As is typical for Doctor Ponytail, she characterizes the diagnosis in a strange and not-entirely-helpful way, in this case likening Cueball's inflamed appendix to a social uprising or rebellion. In some ways, this is not a bad metaphor - Cueball is an organism, and as such, functions best when all of his organic parts are working correctly in unison. People often express the similar sentiment of being "betrayed by their own body" to describe a biological function that isn't working right. However, Doctor Ponytail insists on talking only in metaphor, preventing Cueball from getting any useful medical detail about his condition.

Antibiotic treatment is described as using "chemical / biological weapons", while the appendectomy is described as "victory through the sword". She further describes more extreme "battle tactics", like crushing all other rebellions in his body. Lastly, she mentions "salting his abdomen" to prevent other rebellions. This is a reference to the salting the earth tactic in battle, which

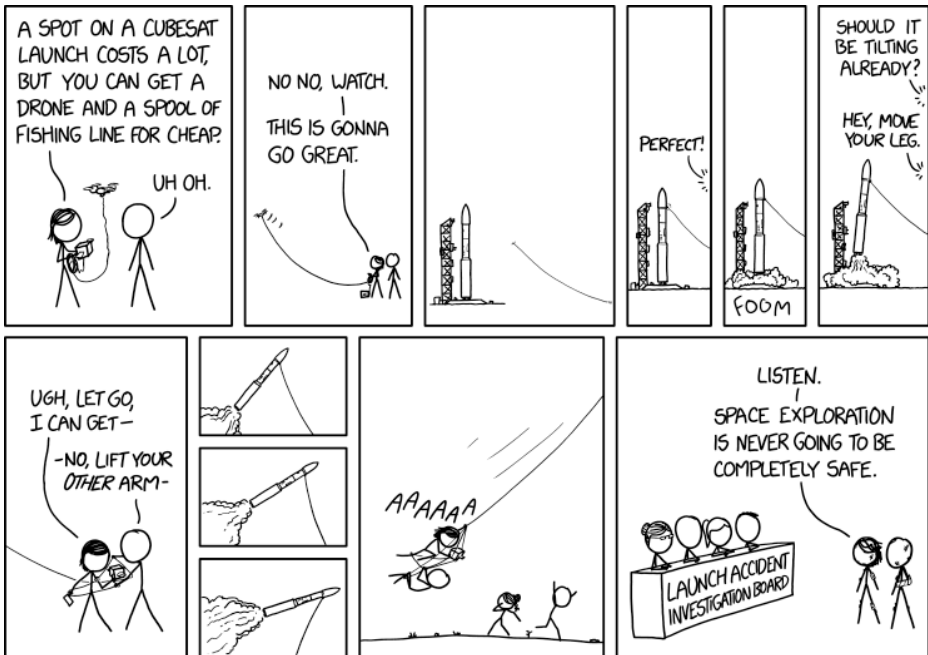
was a ritual to symbolize a curse on a conquered city and would have theoretically hindered future crop production, thus preventing that city from being rebuilt. It is likely that the medical usage would be the application of saline solution, salt in water, which is used for cleaning wounds.

After all this explanation, Cueball begins to question Ponytail's methods, and requests to see a different doctor to get a second opinion.

The title text appears to be Randall speaking directly to the reader addressing a recent appendicitis and his current health state. He continues the comic's joke with a meta reference pondering the repercussions if his organs subsequently discover this comic. The title text of 2508: Circumappendiceal Somectomy, from August 2021, seems to indicate that while antibiotics may have cured this event, a later infection required surgery anyway, a bit more than two years after this comic was released.

## #2148: Cubesat Launch

May 10, 2019



Luckily, the damages were partly offset by the prize money we got from accidentally winning the nearby water skiing championship tournament.

## Explanation

A CubeSat (aka U-class spacecraft) is a miniature artificial-satellite with cubic dimensions of  $10\text{ cm} \times 10\text{ cm} \times 11.35\text{ cm}$  ( $\sim 4\text{ in} \times 4\text{ in} \times 4.5\text{ in}$ ), and masses of about  $1.33\text{ kg}$  ( $2.9\text{ lbs}$ ) per unit. CubeSats are put into orbit from the International Space Station or launched as secondary payloads. As of January 2019, at least 900 CubeSats have successively achieved orbit, and at least 80 have been destroyed in launch failures. Their common functions include: Earth observation, amateur radio transmitters, as well as testing prototype small-satellite technology.

The comic begins with Megan telling Cueball that being officially part of a CubeSat launch is fairly expensive (starting at around \$40,000), but she has an idea for a much cheaper alternative: use a fishing line on a drone to attach to a rocket (that is similar visually to the European Vega rocket) just before launch, with the CubeSat attached to the other end of the fishing line so it gets pulled into space.

In reality, this plan would fail for multiple reasons.

Upon realizing her plan, Cueball immediately responds with "uh-oh", indicating his concern, but Megan assures him that it will be fine, before piloting the drone towards the rocket. She successfully connects the drone to the rocket, and the rocket lifts off.

Whatever her plan was, it goes wrong almost immediately. The unexpected force on the rocket from the side causes it to tilt and go off course. Perhaps if the rocket's control software employed adaptive control techniques, it could have maintained control in the presence of this unexpected force. It is implied that it's not due to the comparatively small force of the CubeSat, but because Cueball is standing on the fishing line. However in real life the force from Cueball stepping on the line would still be very small and would be unable to cause a scenario like this. Megan and Cueball get tangled in the fishing line and are carried away. While the fate of the rocket is not shown, it is likely that its unplanned attitude change would activate the automatic termination sequence or result in manual activation of the destruction protocol.

Megan and Cueball miraculously survive and are brought to an investigative board to explain their actions. Megan attempts to defend herself using flawed logic: something was bound to go wrong sooner or later, so it's not her fault that she was the cause. This logic does not account for the fact that this particular rocket's chance to crash was greatly increased by the drone attempting to connect to it. She isn't totally to blame for the accident anyways, since the launch should have been scrubbed as soon as the drone came anywhere near the rocket, and the failure of Mission Control to do so is negligence on their part, and hence they are more responsible for the failure of the mission than Megan and Cueball as they did not follow proper protocol and allowed the launch to



occur under unsafe conditions.

The title text describes that the supposedly huge amount in damages they had to pay (for all the damage they caused) was partly covered by the earnings from a water skiing championship, which Cueball and Megan presumably won by being dragged across the water by the rocket. This might be a tangential reference to an incident in the Tintin adventure *The Black Island*, where Thomson and Thompson blunder into and win an aerobatics competition when they compel a mechanic with no flying experience into taking off in pursuit of that volume's antagonists. Alternatively, it may simply be a case of the title text being largely irrelevant to the comic itself and simply something Randall found funny.

This topic of CubeSats has been covered in older comics: 1866: *Russell's Teapot* and in 1992: *SafetySat*.

## #2149: Alternate Histories

May 13, 2019



"So their universe wouldn't have the iconic photo of a screaming Truman being hoisted aloft by the newspaper-printing machinery..."

## Explanation

Alternate histories are a common device in speculative fiction. One of the most common (even cliché) uses of alternate history is to posit a world in which the Axis Powers achieved victory in World War II. This is presumably so compelling because it was a relatively recent event in which a series of relatively minor changes could have altered world history in major ways. One of the standard literary works along this line is Philip K. Dick's *The Man in the High Castle*, where the world is split into spheres of influence controlled by the Empire of Japan and Nazi Germany. This novel has been developed into a popular TV series of the same name on Amazon Prime.

At one point, *The Man in the High Castle* discusses the fiction of their own world, which includes their own alternate histories in which the Allies had won the war instead. *The Grasshopper Lies Heavy* is one such novel. Because these stories are speculative, they don't entirely match the 'real' history of our world, differing in key ways. This results in an "alternate-alternate" history where the Allies won World War II, but the details still differ rather significantly than the history of World War II in our reality -- most notably, *The Grasshopper Lies Heavy* depicts a post-World War II world defined by a Cold War between the United States and the British Empire, rather than one between the United States and Soviet Union. In one sense, this functions as a meta-critique of the very concept of alternate histories,

highlighting the reality that we can never know the details of what would have happened if history had gone differently.

In this comic, Megan and Cueball discuss this fictional device. Then in typical xkcd fashion, things start to get exaggerated to ridiculous proportions: Megan points out that, if characters in our stories have their own fiction, then the characters in their stories presumably have their own body of fiction, and so on, creating a recursive loop. If each alternate history contains its own alternate history, presumably each iteration would deviate more and more from our own reality, because each would be speculation based on increasing layers of speculation. Eventually (by the 500th iteration) the history would differ so wildly from our own as to be completely absurd to us, with very few elements being even recognizable.

The 500th iteration timeline apparently includes hovercraft and cybernetic horses. Hovercraft are a real technology which does have military applications as landing craft, but their use in actual warfare has been limited. Cybernetic horses do not exist in our timeline yet[citation needed], but Boston Dynamics is getting close. In our timeline, Scotland is part of the United Kingdom, and would likely not develop military technology independently. New Jersey is a state in the United States and Madagascar was controlled by France during World War II; neither of these would normally be able to pursue an independent foreign policy that would have allowed them to join alliances and fight wars unless their parent governments also did. Belgium was occupied

by the Axis Powers early in the war. These three regions developing a alliance and fighting against Canada (which was also an Allied power) would require a highly unlikely combination of events. How this war would be affected by the lack of Scottish hovercraft is unclear. This scenario also apparently contains a theocracy of some variety in Missouri, which (remarkably!) is vaguely plausible.

Interestingly, even within the bounds of the exceedingly meta-fiction, it is bordering on impossible for the scenario to come into existence; the reason for this is that while the ending would become evermore bizarre, the actual events will only be able to vary so much, as they are based on predetermined scenarios that occur before the changes take place. Unless at least two wars are being modified, or the events are based on a later occurrence, (basically the two are discussing something different entirely, albeit still a historical scenario) the idea of so many implausible things occurring is unlikely no matter what the circumstances, unless they all happened over the course of the war. Of course, it's possible several of those 500 iterations involve BAD alternate histories fiction. Or possibly fiction based on history which was deliberately falsified.

It's unlikely, but it's worth noting that "cybernetic horses" could be a reference to cyber forces, since in 1418: Horse that substitution is suggested.

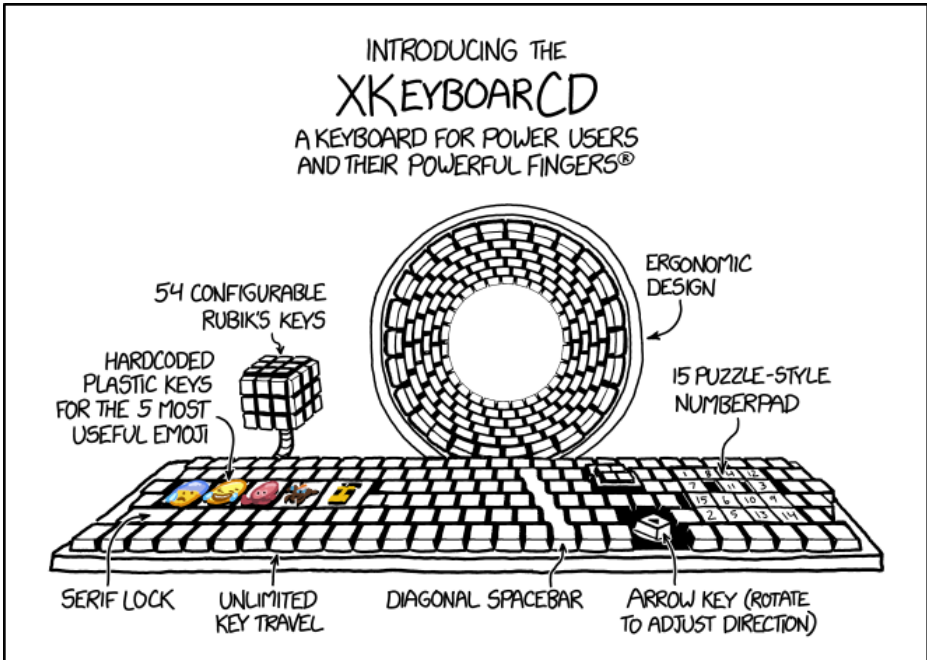
Laura Ingalls Wilder was an American author, best known for her Little House on the Prairie series. In the

500th iteration timeline, she apparently became "God-Emperor of Missouri", despite not being known as a political figure in our timeline. Harry S Truman, in our timeline, became 33rd President of the United States, following the death of Franklin Delano Roosevelt. In the 500th iteration timeline, Truman apparently died in an accident involving pajamas and a printing press (a possibility is that he has big loose pyjamas which get caught in the press) while still a senator (presumably a U.S. senator, since in our reality he was serving in the United States Senate prior to being nominated as Roosevelt's vice president in 1944). He apparently remained a significant enough figure for 500th-iteration Megan to speculate that he would have become God-Emperor of Missouri if he'd survived.

The title text continues the discussion about Truman, mentioning a photograph of Truman screaming in horror as he is hoisted by newspaper-printing machinery. This plays off a famous photograph from our world where Truman is the one hoisting up a copy of the Chicago Tribune in triumph, as said newspaper erroneously claimed he was defeated in the 1948 United States presidential election by Thomas Dewey.

## #2150: XKeyboardCD

May 15, 2019



The key caps use LCD displays for all the vowels, so they can automatically adjust over the years to reflect ongoing vowel shifts while allowing you to keep typing phonetically.

## Explanation

In the same vein (and with the same humor) as the xkcd Phone series, the XKeyboardCD seems to be an overly inventive and borderline ludicrous keyboard intended for some unknown audience. It has an assortment of features (some fairly normal, some more exotic) which give it a..."diverse skill set". This may be in reference to Space-cadet keyboards which were made for programmers and had several keys not present on standard QWERTY keyboards.

XKeyboardCD is a play on xkcd, and keyboard. (XKeyboard CD)

### 54 Configurable Rubik's Keys

The tiles on a Rubik's cube resemble computer keys, so this feature makes fun of that by adding a spinnable Rubik's cube above the keyboard. The implication is that the keys would be 'configured' by twisting the sides of the cube until the desired configuration is reached, although parity means that not all configurations could be reached by conventional means by a 3x3 cube. (Parity exists on 4x4 cubes.) There can be a maximum of 53 keys (the bottom center position can't contain a key because it's the mounting position). Additionally, the top key can't be moved around, so the maximum amount of configurable keys is 52. (The four remaining centers can be moved by rotating the entire cube.) The bottom-facing keys would obviously be hard to



see/reach.

## Hardcoded Plastic Keys for the 5 Most Useful Emoji

This feature parodies the feature of some laptop-keyboards where it is possible to dynamically assign emojis to a small touchscreen area. There is a disaccord between hard-coded, useful and emoji, especially with the large keys in a central position on the keyboard. Which emojis would be "the most useful" is highly subjective.[citation needed] For example, in the comic it shows the quite popular laughing with tears emoji, along with the octopus emoji and horse racing emoji. Notably, the "aerial tramway" was once the least-used emoji, and remains very rarely used.

## Serif Lock

Serifs are small lines on the ends of certain characters in fonts such as Times New Roman and Georgia. It is dependent on the font, not on the character; "A" is represented by the same code regardless of its font. Since a given font almost always either has or doesn't have serifs, this key seems challenging to implement. This key could be implemented, however, by simply changing between a pair of fonts when it is pressed, or by using the characters in the Mathematical Alphanumeric Symbols block. What's more, the button is placed roughly where left shift is on most keyboards, liable to cause frustration.

## Unlimited Key Travel

Key travel is the distance a key moves between its

unpressed and pressed states. In reality, laptop keys only move a few millimeters before bottoming out, and conventional keyboards up to about a centimeter. Increased key travel may make typing more comfortable, up to a point. However, the usefulness of having unlimited key travel is unclear, and the question of how this would be physically possible in the keyboard depicted remains unanswered. The keyboard would have to be infinitely deep to allow unlimited key travel, although pushing it to the near bottom would require infinitely long fingers. At least it is the greatest possible value, trumping any other keyboard.

## Diagonal Spacebar

Instead of a wide key at the bottom that typists can hit easily with either thumb, we now have a tall, narrow key that requires being pressed with the right pinkie. This would not be a good change since most peoples' pinkies are their weakest finger. Some ergonomic keyboards have a slightly curved spacebar or a separated spacebar for each thumb.

## Arrow Key (Rotate to Adjust Direction)

This is essentially a jog dial, or similar rotary encoder. These are sometimes used with keyboards: as controls for volume, video editing, or drawing.

Many computer keyboards have four arrow keys: up, left, right, and down. However, the XKeyboardCD just has one that can be rotated. This has the added bonus of allowing the arrow keys to point more than four

different directions. In a keyboard, it would be awkward to operate as going from horizontally left to horizontally right, for example, would require the user to rotate the key first and then press it, which wastes precious time when playing a video game like the hoverboard comic, where you have to rapidly press arrow keys to move around. It would not let one press multiple arrow keys at once. Trackpoint devices provide similar joystick-like direction function, but are easier to control with a finger.

## 15 Puzzle-Style Numberpad

A 15 puzzle is a square containing fifteen smaller squares and one blank spot, which allows the squares to be moved around. The squares are shuffled and then reassembled as a game or pastime, and are usually labelled 1-15 (as is the case here) or, when assembled properly, create a picture. A numberpad in this style would be frustrating to use for typing numbers, as they could shift (or be shifted) around, but could provide a fun feature to use as a game. Alternatively the keys could be rearranged as with the Rubik's keys. How this would be used to generate numeric input is unclear, but the presence of 16 positions suggests hexadecimal input is possible. Keyboard keypads do have around 17 keys, but only 0-9 usually have numbers whereas the XKCD keypad has numbers 1-15 in the middle of the numberpad probably also surrounded by the more conventional arithmetic operators, enter, and decimal point.

## Ergonomic Design

The cylindrical portion of the keyboard is advertised as being an ergonomic design. Most ergonomic keyboards are both curved into a convex shape and split in the middle, with the blocks of keys on either side rotated around the vertical axis. This is done to follow natural arm and finger movements more closely, that is, avoid forcing the user to rotate their arms and hands to match the flat and rectangular key arrangement of a non-ergonomic keyboard. Some ergonomic keyboards come in unconventional form factors, such as vertical keyboards, to allow the user's hands to rest in more neutral positions or to change positions throughout the day, but the cylinder shape presented here is a concave shape which requires the user to lift and twist their arms to reach certain keys (or roll the cylinder from side to side), which would be an even more strenuous motion than typing on a standard keyboard. The slogan of the keyboard — "for power users and their powerful fingers" — fits this difficulty, but makes no sense as a feature.

The title text references sound changes in languages. Every language (and indeed, every dialect) routinely undergoes changes in its sounds and phonemes, in a mostly regular and systematic, but not totally predictable way (otherways the dialects would sound the same and also the century, when a shift occurs, and the rate of change are not predictable). While not only vowels are affected, in languages with many vowels such as English, they're particularly likely to shift around and/or merge. While having dynamic keycaps that change can actually come in handy, the feature of only having vowels change

in response to sound shifts is a bit less so. One normally enters the spelling and not the pronunciation of words (except with some Asian input systems). The spelling and pronunciation do not change at the same time.

Firstly, while changes in how we pronounce words are always ongoing, the way we write words down tends to stay relatively static, and thahs wiy wuhd faynd thaet werds biykahm ihnkaammpryihhehnsihbuhl duew tuow nhw laager biyigg sphld es thy wor biffrr. Second, English only uses five glyphs (aeiou) and a variety of methods to represent four times as many vowel sounds, so the software would need to have a way to handling that (in some dialects "bird" and "turn" for example, have the same vowel but are represented by "ir" and "ur", as it also can be by the "er" in the bird called the "tern" - or not). Third, vowel shifts are not ubiquitous: the Caught-cot merger, for example, is a phenomenon happening across some parts (but not all) of the US and UK. Therefore, while some people would say "caught" and "cot" have the same vowel it should be spelled the same by the keyboard, but others would say they're two different vowels and should not be spelled identically. Fourth, sound shifts tend to occur over a relatively long period of time (in terms of human lifetimes), so a user would probably find the keycaps only change once or twice. All in all, this is not a very useful feature.

An alternative explanation is that the keys actually map to the International Phonetic Alphabet and converts what you type into English words (and the vowel changes). The IPA is an alphabet used in linguistics and

language teaching, designed to represent every phoneme present in languages of the world unambiguously, with optional modifiers to indicate more subtle nuances in pronunciation, intonation and speech pathology. This alphabet consists of 107 letters and 56 modifiers (with some letters shared with the Latin and Greek alphabets), which would explain the large number of keys. In that case, the feature remains questionable since it only handles vowel shifts and not consonants, and anybody who'd use an IPA-keyboard would probably need to type out the phonology of other languages and appreciate not having to find a key has moved because English has undergone a vowel shift.

#2151: A/B

*May 17, 2019*

I LIKE THIS ONE MORE  
BECAUSE IT ENCODES  
MYCENAEAN GREEK.  
THE OTHER ONE JUST  
LOOKS LIKE GIBBERISH.



## LINEAR A/B TESTING

We wrote our site in Linear A rather than Aksara Kawi because browser testing showed that Crete script rendered faster than Java script.

## Explanation

A/B testing is a form of controlled experiment in which test subjects are randomly split into two groups, A and B, and each group is shown a slightly different version of the same thing. This is most often used for market research, as it allows researchers to discover which of two options are received more favorably by consumers. For example, a website might employ A/B testing by randomly showing 50% of visitors a version with a different font. By checking their site traffic analytics afterward, the site operators can see which version of the site received the most user engagement, which might tell them that the alternate font is a better choice.

Linear A is an as-of-yet undeciphered writing system of the ancient Minoan civilization (a civilization based on the island of Crete). It appears similar to the deciphered Linear B writing system, but if the pronunciation rules of Linear B are applied to Linear A, it produces a language unrelated to any known language.

Linear B, on the other hand, has been deciphered. It is a syllabic script that was used for writing Mycenaean Greek, the earliest form of Greek for which we have evidence. It predates the Greek alphabet by several centuries and likely evolved out of the earlier Linear A writing system.

While not completely consistent with the definition of A/B testing presented above, the comic jokingly suggests

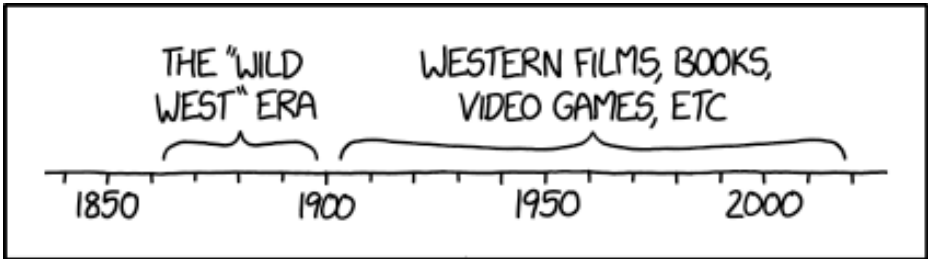


that the choice of writing system could be decided through A/B testing, with the "A" and "B" literally being Linear A and Linear B. The test subject apparently can read Linear B (which encodes Mycenaean Greek), but not Linear A (which produces what's seemingly gibberish when read through the rules of Linear B). It is also a pun on the common phrase "[it's] Greek to me", which people use to refer to something as gibberish, but here, it is the Greek text which is comprehensible to Cueball, while instead the other one isn't.

The title text explains the selection of script code (i.e. programming language) used to create the web site. Aksara Kawi is a script (i.e. a writing system) that was used on the island of Java (today part of Indonesia) from the 8th century until 1500 AD. Referring to it as "Java script" is a pun on JavaScript, which is a browser scripting language for creating web pages. Here, Linear A ("Crete script") is selected as the "script" language over Aksara Kawi because it rendered faster in testing.

## #2152: Westerns

*May 20, 2019*



IT'S WEIRD TO REALIZE THAT THE WESTERN  
GENRE HAS NOW EXISTED FOR THREE TIMES  
LONGER THAN THE TIME PERIOD IT'S BASED ON.

Sitting here idly trying to figure out how the population  
of the Old West in the late 1800s compares to the number  
of Red Dead Redemption 2 players.

## Explanation

The "western" genre refers to narrative works set in the American "Old West" west of the Mississippi River between the years of 1865 (when the Civil War ended) and 1895 (when the US Census officially declared the frontier to be closed). These dates are naturally somewhat arbitrary, but most works in the genre are set more or less in that relatively narrow window of time. This definition may be too narrow, however, as many events related to the American West took place before the Civil War. The fur trade was significant in the western frontier from the early 1800s to about 1845. The Oregon Trail saw its first wagon trail in 1836, and along with variants such as the California and Utah/Mormon trail, was regularly and heavily used beginning around 1845-1847. The California Gold Rush took place in 1849. Stories of fur trapping, wagon trains, and mining all feature heavily in the "western" genre, making the disparity between the length of real history and the length of historical fiction less great.

This era in American history was marked by aggressive settling of western lands. The US had pursued an expansionist policy known as "Manifest Destiny", which had the primary goal of extending US borders across the continent through the means of using Christianity to justify the displacement of Native Americans that were already living there. This led to various strategies to increase the lands under US control (ranging from diplomatic efforts to expansionist wars), displacing,

containing, and eliminating native peoples from the land, and encouraging American settlement in the western territories. Settlers were encouraged to go west with the promise of cheap or free land for agriculture, mineral riches, and freedom from the dangers of large cities.

These sparsely populated lands quickly gained a reputation for being dangerous, unpredictable, and violent. The men and women who settled them were admired as rugged individualists, civilizing a wild frontier through hard work, courage and persistence. The mythos of the "wild west" arguably continues to impact American culture to this day.

The timeline in this strip suggests that the Western genre began almost immediately after the frontier closed. This matches the "official" timeline. The first critically recognized Western novel, *The Virginian*, was published in 1902, and one of the earliest silent films, *The Great Train Robbery*, was made in 1903. However, it should be noted that pulp novels and magazines set in the frontier, as well as "Wild West Shows" that toured the eastern states and Europe had begun decades earlier. And the end of the "Wild West" era can be considered to have lasted into the 1910's, or even the 1920's. In other words, Westerns were an established genre while the real western frontier was still in existence. The genre transitioned from a contemporary setting to a historical one without significant disruption.

The Western genre has varied in popularity, but has never gone away, and continued to produce popular

works throughout the 20th century and into the 21st. Artists who grew up admiring Western heroes have proceeded to use the genre for their own visions, and have reinterpreted the setting across multiple generations, and an evolving media landscape. Literature, music and live performances gave way to film, then television, and now video games. This strip points out the irony that the actual Old West took place over a fairly limited time and space, but the setting has managed to accommodate a genre that's maintained popularity for over a century (at least three times as long as the actual frontier era) and is consumed both throughout the US and across the world.

The title text is in reference to the popular video game Red Dead Redemption 2, which takes place in an Old West setting. Red Dead Redemption 2 has already sold in excess of 24 million copies, while at the 1890 census the entire West - even going by the widest definition, counting every state and territory west of the Mississippi - had a population of just 16.8 million. The region now counted by the US Census Bureau as the "Western United States" was even smaller, at just 3.64 million. Assuming every copy sold represents one player (some sold may not have been played, but others sold may account for multiple players), not only are there more RDR2 players than there were people in the Wild West at its height, there may be more than lived in the region at all during the frontier years.

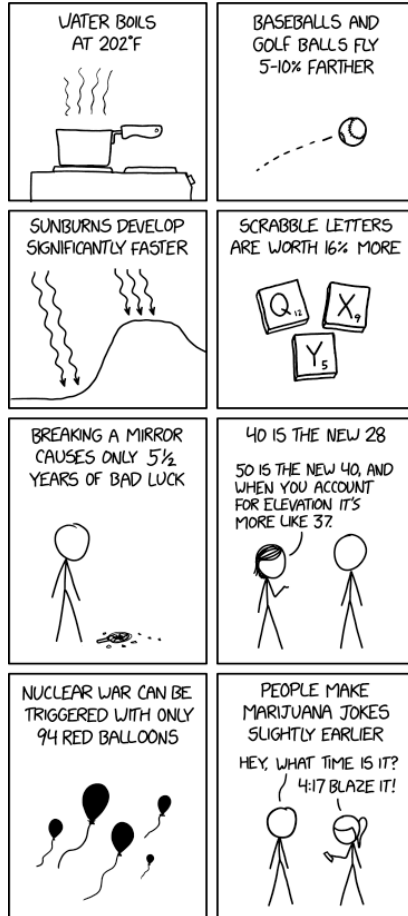
A similar question was asked in the what if? article WWII Films.

## #2153: Effects of High Altitude

May 22, 2019

### EFFECTS OF HIGH ALTITUDE

HOW LIFE IS DIFFERENT AT ONE MILE ABOVE SEA LEVEL  
(E.G IN DENVER)



If she'd lived in Flagstaff (elevation 6,903 feet), Cruella de Vil would only have needed 89 dalmatians for her coat.

## Explanation

This comic starts out with three effects of high altitude related to the air getting "thinner" and the lower air pressure. Denver is one mile (5280 feet or 1609 meters) above sea-level (as marked on the steps of the State Capitol). At this elevation, the average atmospheric pressure is about 83% of sea level pressure, or about 840 mbar instead of 1013 mbar, and gravity is 99.94% of gravity at sea level at the same latitude, or 9.796 m/s<sup>2</sup> instead of 9.801 m/s<sup>2</sup>. This has a number of effects:

- Water boils at 202 degrees F (94 degrees C), slightly lower than the baseline 212 degrees F (100 degrees C) it takes at sea level.
- Baseballs and golf balls fly slightly farther (with the same initial velocity, the distance is inversely proportional to gravitational acceleration so it would be 0.06% farther; in addition, the lower air pressure will reduce the resistance from the air the ball will experience, therefore it will slow down at a lower rate and thus fly even farther than the 0.06% due to gravity).
- Sunburn develops faster because there is less atmosphere above to filter out harmful ultraviolet rays.

As usual for xkcd, the effects of high altitude are extended in a comically absurd manner, applying this "slightly less" rule to things that have nothing to do with altitude:

- Scrabble is a board game where each letter is assigned a point value based on its frequency of use in the edition's language. The comic claims all letters are worth 16% more. When applied to the normal values for the Scrabble tiles in English

Q is worth 12 instead of 10

X is worth 9 instead of 8

Y is worth 5 instead of 4

- A common superstition states that breaking a mirror causes 7 years of bad luck. The comic claims that at higher altitudes, only  $5\frac{1}{2}$  years are caused. This implies that people living at higher altitudes have less bad luck.
- Marketing campaigns will often state "X is the new Y" to draw the audience of Y in toward the newer X. When used with age, usually at 10 year intervals ("40 is the new 30" is the slogan referenced), it is an attempt to convince an older audience that they can share in an experience commonly associated with a younger audience. At higher elevations, the comic claims, people can use or do things designated for an even younger audience. This is contrary to facts however: Most activities, especially in sports, are more difficult at higher altitudes, not easier.

In the base 16 (hexadecimal) number system, the value 28 represents  $2 * 16^1 + 8 * 16^0 = 40$ . Thus, 40 is the new 28. Likewise, in the base 8 (octal) number system, 50 represents  $5 * 8^1 = 40$ . Remember that, although Douglas Adams doesn't write jokes about other bases,



Randall does.

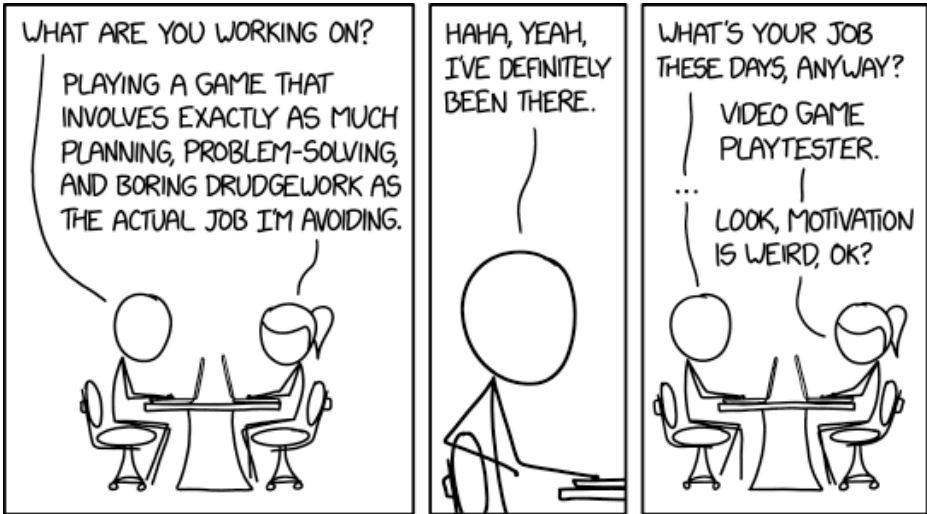
- German band Nena's hit 99 Red Balloons (an English adaptation of the original song called 99 Luftballons) is a song about a war started by a large clump of balloons mistaken for enemy aircraft (see Trivia). The comic claims that if launched from a higher altitude, 94 balloons would have sufficed.
- 4:20 is a code word for cannabis and has evolved in some circles to be the socially acceptable hour to consume cannabis. This has in turn evolved into a joke that when checking the time and finding it is exactly 4:20, people will add "blaze it" as a reference. The comic claims that, at higher altitudes, the socially acceptable time is earlier, so if there is an elevation of one mile, the socially acceptable time would be 4:17 and therefore, marijuana jokes are made earlier. This joke is probably related to the legalization of recreational marijuana use in Colorado.

In the title text, 101 Dalmatians is a Disney franchise (based on a children's book), where the villain, Cruella de Vil, aims to capture and kill 99 Dalmatian puppies (97 in the book) to have the perfect spotted fur coat. (The title includes the parents [book: and other Dalmatian caregivers] of the Dalmatian puppies.) The comic claims that, at a higher altitude in Flagstaff (6903 ft / 2104 m), she would only have needed 89 Dalmatians, possibly implying that puppies at higher altitudes are bigger (perhaps because there is less air pressure to compress them) and/or that Cruella de Vil at high altitudes is

smaller (possibly because of the higher humidity and lower temperature).

## #2154: Motivation

May 24, 2019



What's even worse is, a month ago they transferred me to work on the game I was already playing, and suddenly I found myself procrastinating by playing the one I'd been assigned before. It's possible they're onto me and this is all part of the plan.

## Explanation

Motivation is an important part of human psychology. It arouses a person to act towards a desired goal. It is a driving force which promotes action. As Ponytail is feeling unmotivated to do her job, she decides to procrastinate by playing a video game on her laptop instead, with the hope that she will eventually be more motivated to do her assigned task. Cueball seems to understand her sentiment, and admits to being in the same situation in the past, seemingly assuming she's referring to games that feel like work.

Games are sometimes criticized for feeling like work. This is usually aimed at games that simulate an actual or historical job which can frequently cause the player to have to check each individual plant as if he were an actual gardener, or work out a cost-benefit analysis as if he were an actual manager. This is more generally applied to any video game grinding, also known as farming. This is why when Cueball asks Ponytail what she's doing, she replies that she's playing a game that involves exactly as much planning, problem-solving and boring drudgework as the actual job she's avoiding. Cueball then laughs and says that he has definitely been there before, before asking Ponytail what her job is.

The punch line for this comic comes when Ponytail admits that her actual job is a video game playtester, someone whose job is to test and play video games. So it seems that Ponytail is avoiding doing her task to test

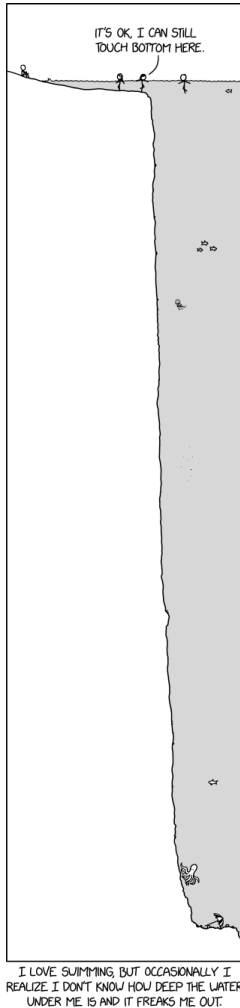
video game X by playing video game Y. As a result, her original statement can be interpreted in a completely different way: Instead of comparing the game she's playing to a regular job, implying that grinding is as difficult and boring as an actual job, playing games is her actual job, and she's simply comparing two games she's playing. Though being a game tester can be seen as glamorous and fun to people who enjoy playing video games ("I get to play video games all day at work"), it is less rewarding than it may seem, as game testers often aren't playing the game but are testing it by constantly doing mundane tasks and running through a game that they may not like to identify bugs and problems, which is far less enjoyable than playing a game one likes for fun, even if it requires a grind.

The title text continues Ponytail's admission, adding that she had originally been assigned to play video game Y in the first place, and was previously procrastinating by playing video game X. Her company may have caught on to her procrastination, as they then changed her assignment to work on video game X that she was already playing to procrastinate. To further procrastinate herself, Ponytail changed to play video game Y, the original video game that she was assigned. However, this would not serve to have her work on her original task to test video game Y. Testing a video game is very different from playing a video game while procrastinating. For example, video game testers must intentionally make "mistakes" to verify that the game responds correctly and, more importantly, report on what worked or didn't work.

Playing normally, while attempting to win, would not yield the data obtained from proper testing.

## #2155: Swimming

May 27, 2019



"You don't know how high above you the sky goes, but you're not freaking out about that." "Well, NOW I am!"

## Explanation

This comic is about an irrational fear about the depth of water beneath oneself, also known as thalassophobia. Whenever you don't explicitly know how deep the water is, and cannot see the bottom, there is nothing preventing the sea/lake/riverbed from being exceptionally far away. This phenomenon is actually quite common with many bodies of water having a relatively shallow shelf extending a short ways out from land. These typically end with little to no warning, giving rise to the fear that is depicted here.

It is an irrational fear because if one is swimming, the depth of the water underneath is not important to safety as long as one can reliably get back to shore. (This fear may be due to excessively worrying about what happens if one stops swimming, thinking that walking should be safer because almost everyone spends more time walking than swimming, ignoring the fact that the safest thing to do in this case is to keep swimming.) If one is wading, presumably one would feel the bottom drop away. Following the safety saying "Walk out, swim back" would help avoid this situation.

Here, Megan and Cueball are in the ocean, with Cueball treading water and Megan standing on the seabed, with another girl in the water and another Cueball watching from the beach. Megan mentions that she can still touch bottom, thus thinking it is safe. In front of her however the seabed drops off steeply, becoming nearly vertical.

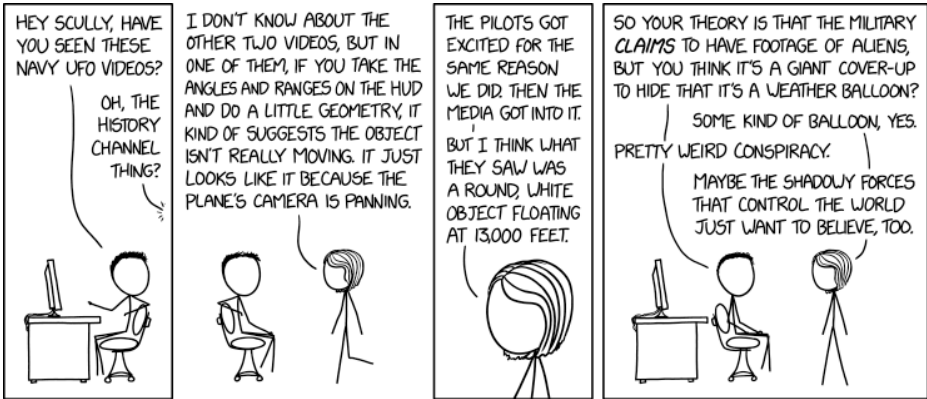


Fish and jellyfish are in the water below, while at the bottom of the frame, but not the sea floor, a small ledge holds an octopus and a beach umbrella. The beach umbrella may be from the beach, to give human scale, though it could also be a Lemmings reference.

The title text alludes to the fact that humans live at or near the bottom of a vast sea of air: the atmosphere. Every day, most people never rise far from the floor of the atmosphere. However, this is nowhere near as perilous as descending to the bottom of a sea of water. Indeed, surviving a rise to the top of the atmosphere requires life support measures. Also, unlike in water, humans are far too dense to "swim" (fly) in the atmosphere.

## #2156: Ufo

May 29, 2019



"It's a little low for a weather balloon; it might be some other kind." "Yeah. Besides, I know I'm the alien conspiracy guy, but come on--the idea that the government would care about hiding something so mundane as atmospheric temperature measurement is too ridiculous even for me."

## Explanation

This cartoon makes fun of conspiracy theories, by suggesting that authorities, like the Navy, could be promoting mysterious explanations for mundane phenomena (such as a weather balloon). UFO is an acronym for an unidentified flying object. This comic is most likely inspired by reports of US Navy pilots seeing unexplained objects. The "History Channel thing" could refer to this upcoming series.

By a weather balloon, it is possible they could mean Cory Doctorow's balloon, which he has appeared in past comics with.

This comic features Fox Mulder and Dana Scully, two fictional FBI agents from the television show *The X-Files*. In the show, Mulder is usually a believer in all manner of conspiracies and supernatural phenomena, whereas his partner, Scully, is reflexively skeptical of any claims of the paranormal.

A fighter aircraft's head-up display (HUD) projects information about the aircraft and its surroundings on a glass panel in front of the pilot. This allows the pilot to fly and fight without looking down at gauges and panels in the cockpit. When the pilot selects a radar contact to track, information including the angle and range to that contact is displayed on the HUD. The HUD is also overlaid on video recorded by the airplane's on-board camera. Scully has examined the tracking information

recorded in one video and concluded that the unidentified object was relatively stationary. Her opinion is that the object is likely a mundane weather balloon, rather than an extraterrestrial craft.

"Maybe the shadowy forces that control the world just want to believe" is an allusion to "I Want to Believe", a phrase from the The X-Files associated with Mulder and his iconic UFO poster.

The title text also contains critique about governments that fail to acknowledge the severity of humanity-induced (anthropogenic) climate change and use their influence to actively hide evidence (such as the US government till 2021 that ordered US government agencies to stop or minimize research and reporting on climate change), which even by Mulder's standards seems too crazy for a conspiracy, yet happens in reality.

The government wanting to cover up a balloon to the point of allowing people to think it was aliens supposedly did happen, as documents declassified in the 90's revealed the existence of a top secret project to use high altitude spy balloons to detect evidence of Soviet nuclear tests, known as "Project Mogul." One of these balloons was the source of the debris in the famous Roswell incident. To maintain secrecy, the government claimed it was instead a weather balloon despite this not being quite consistent with the descriptions of the debris, and how they didn't make an effort to properly refute things when 30 years later UFO enthusiasts started claiming it was an alien spaceship (the whole incident was quite obscure

and quickly forgotten until someone published some claims about the events decades later, in 1978).

## #2157: Diploma Legal Notes

May 31, 2019

### CONGRATULATIONS, CLASS OF 2019!

YOUR DIPLOMA GRANTS YOU MANY NEW POWERS AND PRIVILEGES. THESE INCLUDE:

- YOU MAY NOW LEGALLY PERFORM MARRIAGES AND ARREST PEOPLE.
- IF YOU HAVE YOUR DIPLOMA WITH YOU, YOU CAN USE GROCERY STORE EXPRESS LANES WITH ANY NUMBER OF ITEMS.
- ALL GRADUATES ARE ENTITLED TO DELETE ONE WORD OF THEIR CHOICE FROM THE OXFORD ENGLISH DICTIONARY.
- THE UNIVERSITY WILL MAIL YOU YOUR WORKING LIGHTSABER WITHIN 6-8 WEEKS.
- YOU CAN SEND MAIL WITHOUT STAMPS.
- YOU HAVE EARNED THE RIGHT TO CHALLENGE THE BRITISH ROYAL FAMILY TO TRIAL BY COMBAT. IF YOU DEFEAT THEM ALL, THE THRONE IS YOURS.
- YOU MAY NOW IGNORE "DO NOT PET" WARNINGS ON AIRPORT SECURITY DOGS.

If you're planning to challenge the royal family, you should probably wait 6-8 weeks, since a number of the younger ones have diplomas and Kate was actually on the varsity lightsaber team at St Andrews.

## Explanation

A class of 2019 graduate, presumably for some college or university, is given some rather unusual privileges for graduating.

A common line in degree granting ceremonies is "the degree of X is conferred with all the rights and privileges pertaining thereto." This dates from the Roman Empire and continued through the rise of the university as an institution in medieval times. In the Roman era, the rights and privileges accorded to physicians and scholars included exemption from certain civic duties and military services, immunity from certain levies and from being summoned to court unduly, and even granting a state salary. In the medieval era, rights generally mirrored those of ecclesiastical figures and included immunity from civil law (instead scholars were subject to canon, or church law), as well as safe conduct on their travels between jurisdictions.

While true that some degrees do grant professional privileges today, generally additional accreditation beyond the degree is required (passing the bar, medical certification, etc.) to gain anything most people would consider a privilege or right or incur any obligation. (The obligation to pay your student loans back exists regardless of completing your degree).

The title text builds on the items about lightsabers and the British royal family and advises that, because several

of the younger royals also have diplomas, they have received their lightsaber already. Thus you should wait at least the 6–8 weeks until your lightsaber arrives to have a fair chance, given that the lightsaber is a very lethal weapon. Also some of them may even be proficient with the weapon. Special mention goes to Catherine, Duchess of Cambridge, aka Kate Middleton, who was supposedly on the varsity lightsaber team at St Andrews.



## #2158: Qualifiers

*June 03, 2019*



WHEN I FORGET WHAT I WAS GOING TO SAY, I JUST KEEP PREFIXING QUALIFIERS UNTIL I THINK OF SOMETHING NEW.

[20 minutes later] ", hi."

## Explanation

This comic shows how qualifiers, which are usually used when the person speaking is concerned about offending their conversational partner, may also be used to delay saying something when a person is nervous or loses their train of thought momentarily. Again, this is a comic related to social interactions and especially displaying that Cueball/Randall has problems coping with simple social norms.

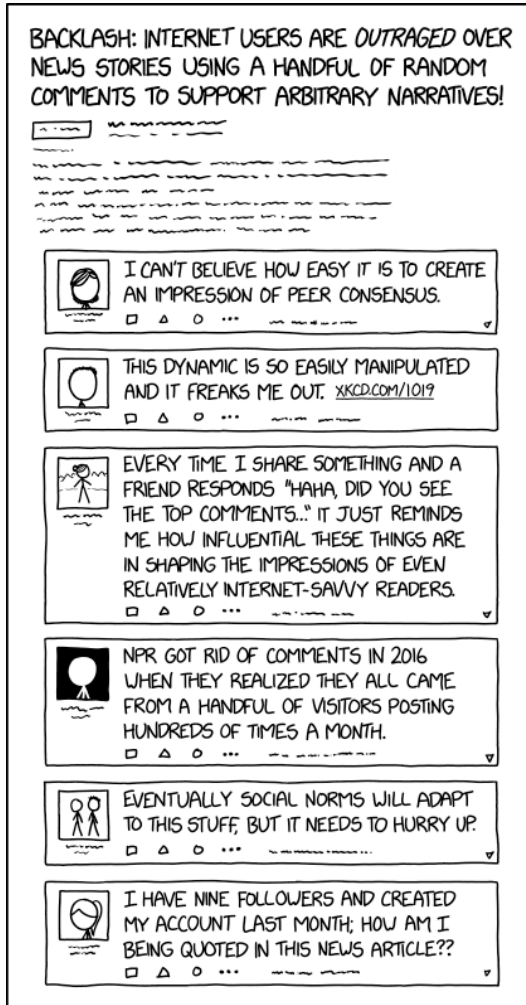
In this comic, Cueball is talking with White Hat. Cueball has lost his original train of thought during a conversation, so he keeps using qualifiers until he comes up with something to say. Here he has used more than a dozen common qualifiers, including "OK", "so", "listen", "like", and "but". The title text says that after 20 minutes he says "hi", a reversal of expectations and a comedic play on how there was a huge buildup to something insignificant. He simply couldn't think of something new to say, and "hi" was the best he could come up with. White Hat presumably kept listening, although normal people would stop Cueball well before this.[citation needed]

While this scenario has probably happened to many people some time in their life, it is highly unlikely that one would keep on for such an extensive amount of time. It is also highly unlikely that the listener would have such patience to keep listening to this endless stream of qualifiers, although it actually fits in White Hat's unusual

mentality.

## #2159: Comments

June 05, 2019



NPR encourages you to add comments to their stories using the page inspector in your browser's developer tools. Note: Your comments are visible only to you, and will be lost when you refresh the page.

## Explanation

This comic represents a news article that bemoans how sometimes lazy journalists will, instead of taking time to research the genuine public opinion on a certain issue, simply cherry pick comments as evidence to support their thesis. The irony is that the article is likely basing its own narrative of outrage among Internet users on random comments as well. For example, an anonymous Twitter account from Northern Ireland with 159 followers got used as an example in the first paragraph of a NY Times article about how U.S. Millennials think.

The commenters create the narrative here, by pointing out how easy it is for commenters to push a point of view, and how little editorial control or fact checking there is in such a process. The final commenter reveals that the article itself is cherry picking from a handful of random comments to support its arbitrary narrative of internet outrage, proving the real joke.

The link in one of the comments is to 1019: First Post, which also refers to manipulating comments to change public opinion of a topic. It specifically mentions "creating an impression of peer consensus", a line which is near-quoted in the first comment included in this comic.

Another comment mentions a National Public Radio ("NPR") decision to remove comments from their website in 2016 because they represented only a tiny

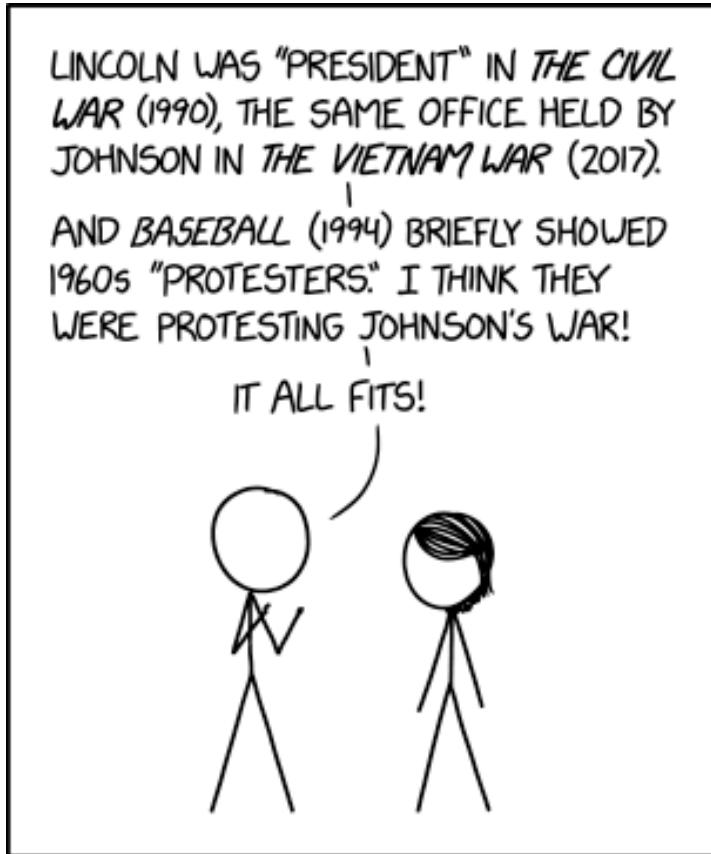
fraction of their readers. The statement released by NPR suggested they had decided to use social media channels to engage readers instead of using an on-site commenting system.

The last of the comments may be from the user "Mary" who, in the NPR article, was explicitly cited to have said that the comments have been too violent. But it is unclear how this is possible given that this article claims to have been published after the comments having been turned off. This may also be a reference to 1303: Profile Info, as both of the characters would decrease the efficiency of the ad/article by being chosen as a quote.

The title text refers to the ability to edit webpages using in-browser tools, like "Inspect Element." However, such changes are temporary and only on the machine used for viewing the web site; anyone else loading the page will not see them, and refreshing the page causes the changes to be replaced with the real content. This would mean that no other users would be able to see the comments, and news sources could not use them to influence public opinion.

## #2160: Ken Burns Theory

*June 07, 2019*



I HAVE A FAN THEORY THAT EVERY  
KEN BURNS MINISERIES EXISTS WITHIN  
A SINGLE COHESIVE UNIVERSE.

Some of the KBCU ancillary works try a little too hard to tie everything together. Doris Kearns Goodwin, the sports journalist featured in "Baseball," was somehow **ALSO** a famous historian who wrote bestselling biographies of

Lincoln AND Johnson? Unrealistic.



## Explanation

Some fiction writers and filmmakers deliberately set some (or all) of their works in a common, or shared, universe, meaning that characters in one work can conceivably meet characters in another work via conventional travel, and sometimes such crossovers are made canon. In other cases, though, fans will hypothesize that a set of works take place in the same universe, even if the creators don't make such connections explicit (or even outright deny it). In such cases, fans will often pick out elements of different works, and find ways to relate them to a common storyline, creating a meta-narrative, in which each individual work is part of a larger timeline (some examples of such fan theories described in this Mental Floss article).

Ken Burns is an American filmmaker renowned for his historical documentaries; thus, all his documentary series are set in a common universe - namely, the real one - and usually the setting is a small part of that (real) universe: the United States in the last two centuries. The series mentioned are

- The Civil War, covering the history of the American Civil War (1861-1865), released in 1990.
- The Vietnam War, covering the history of the Vietnam War (1955-1975), released in 2017.
- Baseball, covering the history of baseball from the

1840s to the 1990s, released in 1994.

The joke here is that Cueball is trying to find the common features between Ken Burns' series to set them in a common universe, as a fiction fan would do, "discovering" similarities between series that are simply facts in American history. For example, several series have an office named "President", which Cueball "guesses" to be the same for Lincoln and Johnson, and which obviously is just the President of the United States. Cueball has also drawn inferences from facts established in one series to draw conclusions about another, when he (correctly) concludes that the 1960s protesters depicted in Baseball were protesting "Johnson's war" as depicted in The Vietnam War.

The title text continues the joke by saying these stories are set in the "KBCU", an acronym which stands for "Ken Burns Cinematic Universe" similar to the popular Marvel Cinematic Universe (MCU).

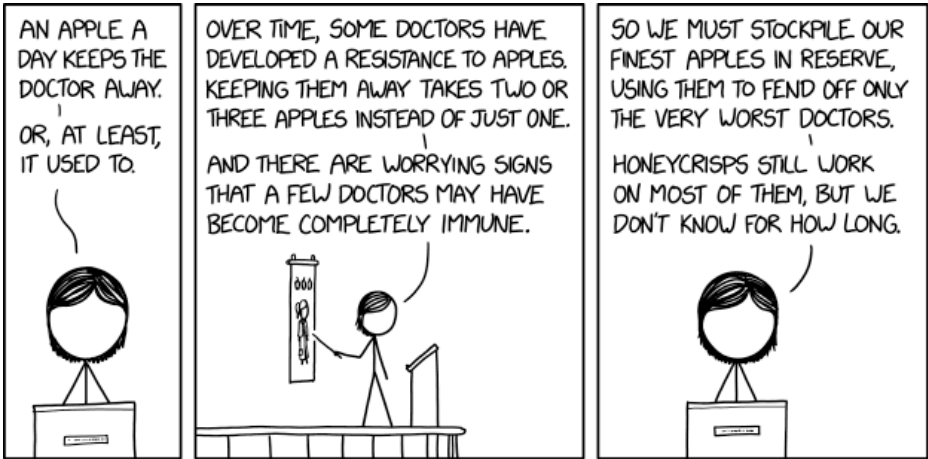
Doris Kearns Goodwin, mentioned in the title text, is a famous historian who has written biographies of several U.S. Presidents. She is also a fan of baseball's Boston Red Sox and a sportswriter who appeared in the Baseball miniseries. Cueball states that having a character that had written biographies of both presidents, while also a sportswriter was "unrealistic". It's not uncommon for writers trying to fit different stories into a single 'universe' to cause a single character to become important in both, even though it makes little narrative sense. This can be denounced as "trying too hard" to fit the stories

together.

Finding that certain aspects of reality seems unrealistic is quite common. This is because our judgment of realism is based on our own experiences and our (often flawed) perception of probabilities. Because the complexities of the world generally exceed any person's experience, and because it's natural for highly unlikely events to occur sometimes, real events can seem implausible. In this case, people tend to think of sports journalism and political biography as being very different fields. The odds that one person would do work in both fields important enough to be relevant to all three documentaries under discussion feels unlikely. As a result, we (or rather, Cueball) deem it as unrealistic, even though it actually happened.

## #2161: An Apple a Day

June 10, 2019



Even the powerful, tart Granny Smith cultivar is proving ineffective against new Gran-negative doctors.

## Explanation

"An apple a day keeps the doctor away" is a common English proverb and rhyme. The suggestion is that eating one apple daily will keep you healthy, and therefore reduce your necessity to go to the doctor or, more literally, to have the doctor come to you as was likely the case when this proverb was first used.

Megan is giving a talk, starting with the common proverb, before continuing with "At least, it used to." In a normal scenario, this might have been to imply that eating apples is no longer enough to stay healthy. However, in this comic, this expression is reinterpreted to mean that an apple used to repel a doctor. It also suggests that keeping doctors away is of great importance, presumably because doctors in this scenario are undesirable. The method of action of apples is not specified; they could act as repellents, analogous to insect repellent, or possibly as lethal agents, as antibiotics are to bacteria, or fungicides are to fungi.

Megan continues with her reinterpretation, mentioning that doctors have become resistant to apples so two or even three may be needed. As control agents become more widely used, organisms which are less sensitive to the control may become more common, as is happening with mosquitoes becoming insensitive to repellents, or antimicrobial resistance, and pesticide resistance. Such resistant organisms may require higher doses, or use of multiple control agents.

In the worst cases, doctors have become completely immune to apples (i.e., superbugs). A poster behind Megan shows Doctor Ponytail with three apples above her. Megan advocates using the 'finest' apples only in these cases (a reference to multidrug-resistant pathogens, where some antibiotics are only used as a last-resort to reduce the development of resistance to them).

This comic is a clear reference to the overuse of antibiotics in modern society, leading to an increase in antimicrobial resistance ("Superbugs"), which has seen increasing awareness in the last few years. The World Health Organization had the first Antibiotic Awareness Week in 2015, where a talk similar to the one in the comic would seem appropriate. Similar problems occur in growing plants, where various pests (whether insect, fungi, microbes, or plants) adapt to control measures, making control less effective.

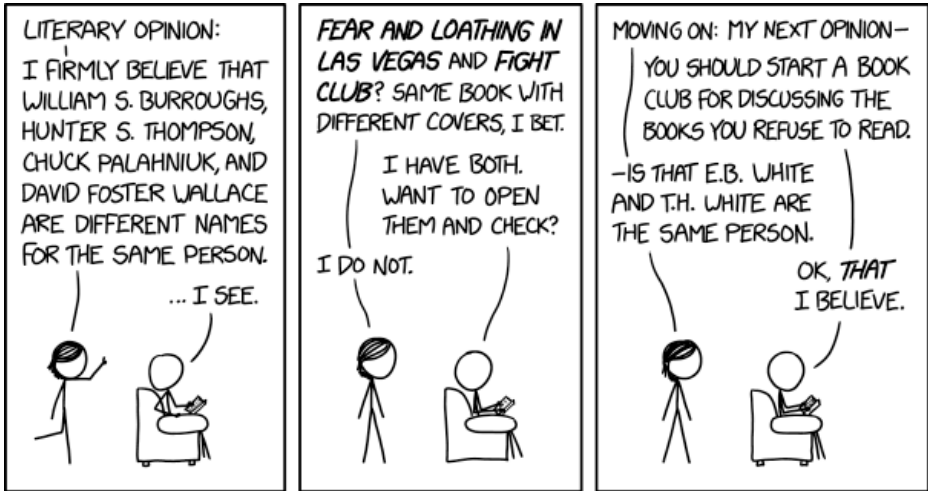
In the title text, this is taken further: "Gran-negative" is a pun on Gram-negative, a category of bacteria. A well-known technique called Gram staining distinguishes two classes of bacteria (Gram positive versus Gram negative) on the basis of properties of their cell walls. In this case, Granny Smith apples are supposedly effective against Gran-positive doctors (since the name begins with "Gran"), making them ineffective against new Gran-negative doctors.

Honeycrisp and Granny Smith are two different cultivars of apples. Granny Smith apples are a refreshingly tart green apple, which have mixed reviews among apple

eaters; they are used primarily for cooked dishes, rather than eating raw. Conversely, Honeycrisp are a very sweet apple, considered by some to be "an ideal apple for eating raw", and is the state fruit of Minnesota.

## #2162: Literary Opinions

June 12, 2019



If I really focus, I can distinguish between John Steinbeck and John Updike, or between Gore Vidal and Vidal Sassoon, but not both at once.



## Explanation

Megan is telling Cueball about some of her literary opinions: She believes that William S. Burroughs, Hunter S. Thompson, Chuck Palahniuk, and David Foster Wallace are different names for the same person. Many authors write under pen names for some of their works, or even several different pen names. Sometimes people come to believe that different people are actually a same person, which is known as the Fregoli delusion; the person is usually believed to change appearance.

She then says that *Fear and Loathing in Las Vegas* (by Thompson) and *Fight Club* (by Palahniuk) are the same book with different covers, probably because the title and promotional images for both hint at fighting taking place in a big city (i.e., she is literally judging the books by their covers), when in reality the books are vastly different. Books sometimes have different covers and titles in different regions. That said, *Fight Club* does contain a plot twist where two "different" things turn out to be the same thing (see 109: Spoiler Alert for more information).

Cueball's attempt at a reality check (proposing to actually open the books she is talking about) is met with disinterest. It becomes clear that Megan just wants to share her weird beliefs and does not care if they can be proven false - a theme that previously appeared in 1717: Pyramid Honey.

As a last resort, Cueball humorously proposes she should start a book club to discuss the books she has not read. This may be to congregate all people who criticize books without reading them, or in hopes that it will be attended by people who have read the book and can prove to Megan her opinions are baseless.

Megan finishes telling him her opinion anyway, which is that E.B. White and T.H. White are the same person. This is apparently an opinion that Cueball can agree with, as he tells her that he believes it. This is likely a joke that the two names are hard to distinguish due to the having the same last name with only initials instead of a first name. In reality, the books they authored are very different, with E.B. White writing children's books (Charlotte's Web, Stuart Little, etc.) and T.H. White writing adult books about King Arthur (The Sword in the Stone and its sequels), although his works were adapted into a Disney movie so they could, to some degree, be considered children's books.

The title text continues with this, with Megan saying that she can distinguish between John Steinbeck and John Updike, or between Gore Vidal and Vidal Sassoon, but she can't do so simultaneously. Again this is likely due to the similarities in their names. However, John Steinbeck and John Updike are also easy to confuse because they are both giants of 20th century American literature, whereas Gore Vidal has almost nothing in common with Vidal Sassoon (see chart below).

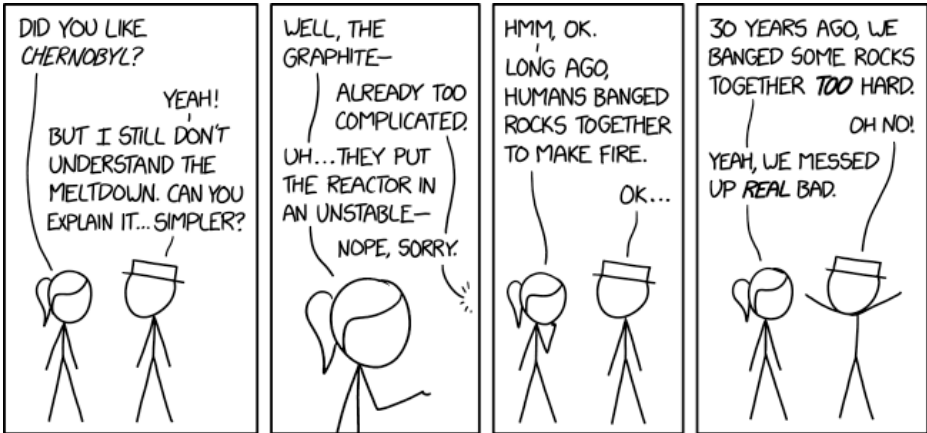
Additionally, the mention of simultaneity could be a nod

to the Heisenberg uncertainty principle, which states that there is a trade-off in precision when simultaneously measuring position and momentum. It could also be a nod to how the brain cannot simultaneously interpret two different things at once, similar to looking at the Rabbit-duck illusion; at any moment, one can only see a duck or a rabbit in the image, but not both at exactly the same time.

**Explanation of people mentioned[edit]**

## #2163: Chernobyl

June 14, 2019



You know when you can't hear your speakers, and you keep turning various volume controls up higher and higher in confusion, and then someone hits the mute button and there's a deafening blast of sound? That's basically what happened at Chernobyl.

## Explanation

Ponytail and White Hat discuss the HBO miniseries Chernobyl which depicts the 1986 Chernobyl nuclear plant meltdown and the fact that none of them needs to state that they refer to the series, not to the power plant shows the impact the miniseries had on language, at least at this time. White Hat asks Ponytail for an explanation of how the meltdown occurred, but his understanding of science is so limited that he finds even the first part of the first sentence of Ponytail's explanation too complicated to understand.

Ponytail starts explaining the role of graphite in the reactor's core as the neutron moderator, but White Hat immediately interrupts her, as if he doesn't understand the word graphite. Ponytail tries starting the explanation from another angle, stating that the nuclear reactor was inadvertently put in an unstable state moments before the disaster, but White Hat interrupts again. Realizing that White Hat does not understand what a reactor is, even though the reactor is the entire subject of the reactor meltdown, Ponytail resolves to use plain words every person should know, and to employ a metaphor.

She compares the purpose of a nuclear reactor as a heat-generating device to primitive humans' way of heating by starting a fire. She goes on describing how a fire can be started by banging rocks (pieces of flint) to create sparks, which in turn would light a fire. Seeing that White Hat understands this simple activity, she compares

starting a runaway nuclear fission reaction to banging rocks too hard, presumably splitting or crushing them and injuring the wielder.

Nuclear reactions are often simplistically described and illustratively pictured as forcibly colliding colored balls representing various nuclear particles or nuclei, resulting in creating other balls, joining some into bigger ones, or splitting some into smaller ones. Fission reaction, in particular, involves a neutron causing a heavy nucleus to split into smaller parts, including more neutrons, that may cause further splits, and so on. To facilitate nuclear reactions, particles need to carry great amounts of energy as compared to their tiny sizes and masses. This may evoke a mental image of hitting rocks too hard so they split.

Alternatively, banging some rocks too hard may suggest to a person not entirely familiar with the process of starting fire by the use of flint, that instead of providing small sparks and lighting a controlled fire by striking flint moderately, overdoing it may create a huge uncontrolled fire – and it is what has happened in Chernobyl, a huge fire caused by reactor overheating and subsequent explosion and core meltdown, with additional harmful effect of spreading radioactive particles over large area by the fire's fumes.

The title text explains the cause of the accident using an analogy with the volume of an audio system. To sustain a controlled nuclear fission chain reaction, various mechanisms are involved in controlling the level of

neutrons produced and consumed by the nuclear fuel. Due to various design flaws and operation errors leading up to the Chernobyl disaster, the reactor core was producing less heat than desired by the reactor operators, who were preparing to conduct a simulated power outage experiment. To increase heat production, the operators pulled out almost all available control rods without diagnosing the cause first, akin to turning the volume knob to maximum on a sound system while there was no signal on input because of some condition independent from volume setting and not readily recognized by the operator. Then the commencement of the experiment, which reduced the coolant water supply, further enhanced the positive feedback loop of the neutron production. Seeing a rapid rise in the power output, the operators began an emergency shutdown. A critical design flaw of the reactor caused the neutron production to increase temporarily in the reactor once the emergency shutdown started in this condition, which resulted in a runaway reaction caused by the multiple positive feedback loops taking place, ending up with dramatic increase of generated heat, coolant water rapidly boiling, steam explosion breaching the pressure vessel and breaking the coolant lines, and melting of the reactor core. The extreme heat of the melted core caused remaining water to split, and the accumulated hydrogen finally caused a chemical explosion that finally destroyed the reactor. Per the title text, this is analogous to a input signal returning to normal on a sound system that has the volume turned all the way up, creating a "deafening blast of sound."

## #2164: Glacier

*June 17, 2019*



The Norwegian adaptation of *The Sword in the Stone* takes things in a weird direction.



## Explanation

A glacier is a wall of dense ice. Though glaciers tend to appear still, they are actually slowly moving, typically by around 10 inches (25 cm)/day.

Beret Guy and Knit Cap are facing the forward edge of a glacier. Knit Cap remarks that glaciers are amazing, mentioning the fact that though we can't see it, the ice is slowly advancing. After considering this, Beret Guy leaves, then returns with two sabres and a hairdryer. He uses the (apparently battery-powered) hairdryer to melt a small cavity into the glacier, which he then lodges the sabre into. The melted pocket then freezes over the sabre; Beret Guy then takes a defensive position. "Advancing" is a basic forward movement in fencing, and Beret Guy appears to feel it is unfair for the glacier not to have a weapon.

The title text refers to The Sword in the Stone, a famous sword in the legends of King Arthur, and Norway, a country known for its glaciers. In the original legend, the sword is set into solid rock, and enchanted so that only the true King could draw it out. The legend has been alluded to in a previous comic. The title text might be making any of several implications about a Norwegian adaptation, including:

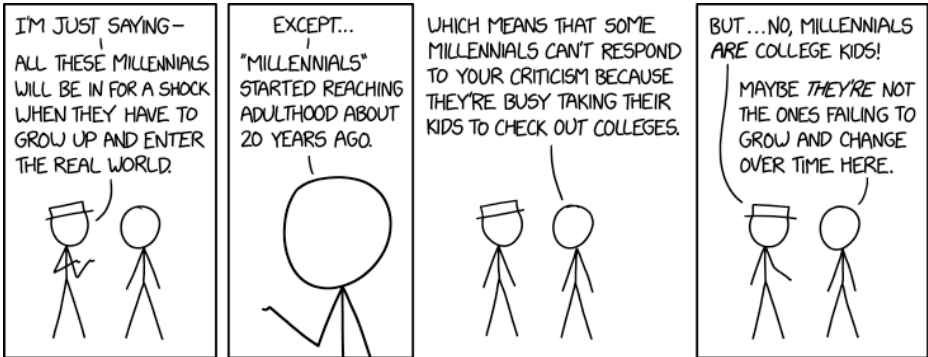
- The sword would be set into ice, a much less reliable and more easily-bypassed substance than stone.
- The sword would be set in the stone (or ice) hilt-first,

meaning the true King would need to pull it out by the blade.

- The true King would not remove the sword, but rather would embed it into the stone (or ice) as Beret Guy has done here. – As Terry Pratchett wrote: "What's so hard about pulling a sword out of a stone? The real work's already been done. You ought to make yourself useful and find the man who put the sword in the stone in the first place, eh?"

## #2165: Millennials

*June 19, 2019*



Ironically, I've been having these same arguments for at least a decade now. I thought we would have moved on by now, but somehow the snide complaints about millennials continue.

## Explanation

According to the definitive chronology of generations, millennials are born between 1982 and 1999. Those born in 1982 reached adulthood (18 years) in 2000. As of writing of this comic (mid 2019), this is about 20 years ago. When the term became widespread around 2012, replacing the previous term "Generation Y", the average millennial was 21 years old, so the image was popularized of millennials as "college kids". The parlance of the word in everyday usage seems to be expanding so that it now includes not just those that were originally Gen Y, but also some younger Gen Xers, as well as current teens and college kids (many of whom are actually Gen Z/Generation ). This trend may continue well into the point of Zuckerberg's Army becoming college kids.

In this strip, White Hat expresses a sentiment of prejudice against millennials, claiming they aren't prepared for "the real world." This is a sentiment that sometimes can be found among those of older generations.

However, Cueball refutes this by saying that many millennials have been adults for almost 20 years, and those that had kids early on are taking them to college. This is due to another common misunderstanding, where the definition of "millennial" has changed so much, and expanded so often, that nobody really knows what it means anymore.

White Hat refuses to accept this, saying millennials are

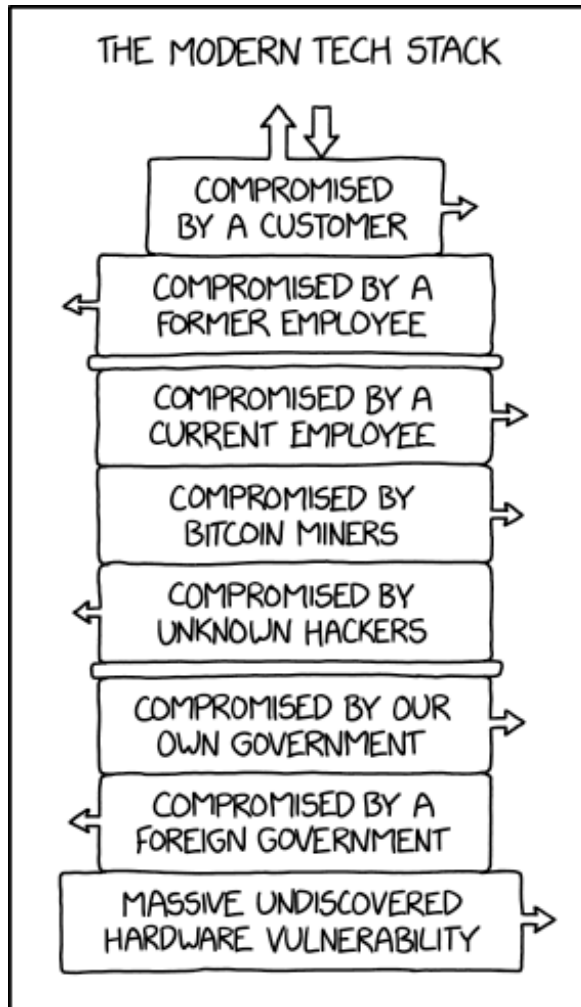
the college kids, to which Cueball says that maybe White Hat is the one not growing up and accepting that millennials are, in fact, adults. The title text builds on this, complaining that Randall has been having these discussions for over a decade.

The title text begins with the word "ironically," for what appears to be an entirely sincere complaint, possibly in reference to Alanis Morissette's pop song "Ironie," which is often said to be a generation-defining hit among millennials, and which was widely criticized for misusing the word. Alternatively, Randall may simply be using "ironically" to mean "strangely".

White Hat has been similarly confused by what ages different generations are in 973: MTV Generation.

## #2166: Stack

June 21, 2019



Gotta feel kind of bad for nation-state hackers who spend years implanting and cultivating some hardware exploit, only to discover the entire target database is already exposed to anyone with a web browser.

## Explanation

In software engineering, a tech stack is the set of technology platforms and tools that a company or app uses. A common tech stack is GLAMP, composed of a GNU/Linux operating system, an Apache Web server, a MySQL database, and the PHP programming language.

In this instance, all of the layers represent systems which have been subverted or compromised ("cracked") by various entities, instead of various software technologies. The stack resembles an OSI network architecture, with an eighth layer added representing the user itself.

Compromised by a customer: The user experience, above the OSI layers. Compromised by users doing something wrong or ill-advised.

Compromised by a former employee: In the OSI model, this would be the application layer. The application may include a hidden spyware in its codebase. An example of such a compromise, or the following, is that which involved the Desjardins Group.

Compromised by a current employee: This is the presentation layer. See above. Possibly compromised by a mistake of a current inexperienced employee.

Compromised by Bitcoin miners: This is the session layer, where SSL historically resided. Cryptographic exploits may cause compromise of whole communication. Examples of compromise: Dozens of

bitcoin mining viruses, and the main challenge of Bitcoin itself (reversal of SHA-2 256).

Compromised by unknown hackers: This is the transport layer. IP and port spoofing is a possible compromise.

Compromised by our own government: This is the network layer. It refers to communication intercepts by governments. Examples of compromise: Cisco (for US citizens)

Compromised by a foreign government: This is the data link layer. This layer may be compromised by malrouting packets. Examples of compromise: Huawei (for non-Chinese citizens)

Massive undiscovered hardware vulnerability: This is the physical layer. An undiscovered hardware vulnerability may cause compromises further up in the stack. Examples of compromises:

Intel Management Engine, Meltdown, Row hammer

In the title text, Randall expresses sympathy for a situation where someone spends a significant length of time on something that then becomes completely unnecessary. In this case, it's the state-sponsored hackers who develop an exploit of some hardware component, which then becomes completely useless because the target database on that hardware is totally open anyway to anyone with a web browser (which is essentially everyone). While he's not suggesting he agrees with their



hacking, he has some sympathy for their wasted effort.

## #2167: Motivated Reasoning Olympics

June 24, 2019



[later] I can't believe how bad corruption has become, especially given that our league split off from the statewide one a month ago **SPECIFICALLY** to protest this kind of flagrantly biased judging.

## Explanation

Cueball is talking to Ponytail about the trophy he won for winning the “Motivated Reasoning Olympics” (hence the title). Ponytail rightly points out that the trophy says he only got second place. Cueball then displays the “motivated reasoning” skills that won him the trophy, by claiming that the athlete who beat him cheated in an earlier round and that the judges were “certain” to disqualify him after reviewing. Here, the cognitive dissonance that should result from believing that he won first place but having a trophy that says second place is reduced by Cueball’s motivated reasoning. He has developed a narrative that explains away the inconsistent fact of the label on the trophy, and thus, convinces himself that there couldn’t have been any shortcoming in his own performance. These are all characteristics of motivated reasoning.

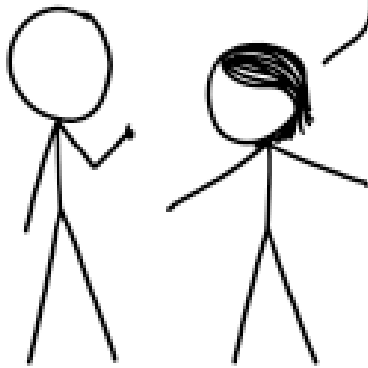
The title text is a continuation where Cueball suggests the judges are biased in favor of the original winner, whom they approve of. He further states that this is evidence of corruption and is the reason why his league split off from the official state-sponsored league just prior to the Motivated Reasoning Olympics. Of course, motivated reasoning is an emotion-biased decision-making phenomenon, by definition, so he should expect the judging to be biased.

## #2168: Reading in the Original

*June 26, 2019*

IT'S IN THE "LANGUAGES" BOX IN THE LOWER LEFT. IT TOOK A WHILE TO LEARN, BUT I FIND I GET SO MUCH MORE OUT OF IT BY READING IT AS IT WAS *INTENDED*.

THAT'S NOT HOW THAT WORKS!



PEOPLE GET MAD WHEN I TELL THEM I ONLY READ WIKIPEDIA IN THE ORIGINAL GREEK.

The articles are much shorter, but I assume that's because this version predates the merger with the Hawaiian text that created the modern Hawaiian-Greek hybrid wiki-pedia.

## Explanation

Many academics and aficionados argue that studying texts in the original language is more valuable than reading translations. The argument is that translations are rarely able to fully capture all of the nuances, linguistic subtleties and intent of the original author, and may even alter the meaning in some way due to the translator's interpretation and word choices. The drawback to this is that it requires the reader to be sufficiently fluent in whatever language the text is written. Critically, a reader of the original source also needs to understand the cultural and historical context of the original work, something a professional translator might deal with much better. This can even happen when working with archaic texts in the same language, as certain references and phrases may have had a significance which was lost over time.

Cueball's commenting that he read works "in the original Greek" implies a high-level of literary scholarship, as this phrase is associated with scholars studying ancient Greek texts, which form a significant part of the foundational works of Western literature.

A similar thing happens with dubbed movies or TV series/anime, with many people remarking that they instead prefer to watch the original version (sometimes with subtitles), instead of the dubbed version.

The joke in this comic is that Cueball has apparently

taken the time to learn Greek in order to read the Greek-language Wikipedia in that language, believing it to be the "original" one. Wikipedia was originally launched as a single English-language edition encyclopedia, but Cueball apparently treats it as though it was originally written in Greek. (An Ancient Greek Wikipedia test project also exists, but is not nearly as large as the modern Greek one and isn't available through the languages box.) Wikipedia has editions in about 300 languages; the 'languages' box that Cueball mentions does link to the corresponding page in other languages when they are available, but such pages are not usually translations of each other, having been written separately. (The 'languages' box was indeed placed in the lower left of the page at the time the comic was published, but moved to the upper right in January 2023, when a new default Skin was deployed.) Cueball's dedication to appearing to be a committed scholar is therefore contrasted with the ignorance of not understanding that Greek is not the original language of every text. Megan, recognizing that Wikipedia articles were not originally in Greek, exclaims that "That's not how that works!"

The movie *Star Trek VI: The Undiscovered Country* has a joke concerning someone speaking of a foreign "original" language of something that actually was originally written in English: Chancellor Gorkon says, "You have not experienced Shakespeare until you've read it in the original Klingon." (In context it's heavily implied Gorkon is speaking in jest, and he is well aware

Shakespeare was a human who wrote in English, not Klingon.)[citation needed]

The title text combines two jokes. First, the reference to pages being "much shorter" is because the English language Wikipedia has the most editors and is the most developed; outside of areas of intense interest to Greeks, most pages would be more complete on the English Wikipedia, which would normally be a sign to Cueball that his interpretation that Greek was the original text is incorrect. Second, the way he explains away this contradiction is an etymology joke, since "Wikipedia" was coined from two parts, "wiki", from Hawaiian, and "pedia", from Greek. However, words having roots in different languages is common and does not signify any link between the separate languages; for example, while the word "Wikipedia" does have etymological roots in Hawaiian and Greek, it is not true that the site was originally composed of texts written in Hawaiian and Greek. In Hawaiian, wiki means quick. In Greek, the suffix pedia is related to learning, which makes Wikipedia mean "quick learning" when combining these two languages.

## #2169: Predictive Models

*June 28, 2019*



WHEN YOU TRAIN PREDICTIVE MODELS  
ON INPUT FROM YOUR USERS, IT CAN  
LEAK INFORMATION IN UNEXPECTED WAYS.

WE WILL ARREST THE REVOLUTION MEMBERS [AT THE  
JULY 28TH MEETING][tab] "Cancel the meeting! Our cover  
is blown."



## Explanation

Predictive text is a feature on many systems whereas you type the system automatically suggests likely words or phrases to follow what you have written to that point. For instance, if you type "I'm heading" the system may suggest "home" or "back" as likely words to follow. Predictive systems usually use prior input to generate their predictions, so if you frequently type "Totally amazing!" the system will suggest "amazing!" every time you type "totally" even if you actually go on to type "totally true" sometimes.

In the comic, Cueball is using predictive text to uncover a plot against his organization/government, but instead of using only his personal input, the system is using input from all users. By typing in an obscure phrase related to revolution and a meeting, he gets the predictive text algorithm to display where and when the next supposedly secret meeting will be held based on other users input. This works because it is unlikely that anyone else other than revolutionaries would be typing this phrase, thus the only data the algorithm has to predict from is the actual message from the revolutionaries on their next meeting. The caption of the comic is pointing out that systems which use prior input for predictive purposes in this way can end up leaking information that might otherwise be considered private. (However, this method may produce outdated information. On June 29, 2019, typing in Google "Long live the revolution. Our next meeting will be at" gave the predicted

completion "long live the revolution. our next meeting will be at comic con 2018", which would not be useful information to anyone looking for revolutionaries, because Comic-Con 2018 was already over.)

The title text shows the revolutionaries using the same technique. By typing in "We will arrest the revolution members" they are hoping that the algorithm will suggest the time and date of their planned arrest, since no one other than the authorities would be typing in that phrase. Pressing the key [tab] to autocomplete that text produces "WE WILL ARREST THE REVOLUTION MEMBERS [AT THE JULY 28TH MEETING]", and the revolutionaries then say "Cancel the meeting! Our cover is blown." The revolutionaries have apparently made the serious mistake of holding secret meetings on regular, predictable dates (such as the 28th day of each month, the last date guaranteed to exist in any month of the Gregorian Calendar), and the authorities have successfully figured this out, either through the predictive-text attack or by other means.

Both examples assume that the revolutionaries and the authorities would be talking about very secret information in the clear on a network accessible to their adversaries. In the real world, people engaged in sensitive activities would communicate via code, encryption, or both, or would do so through what they believe to be secure channels. There is still the danger of secret information leaking via non-secret channels, however. Side-channel attacks use information gained from the implementation of a system to deduce supposedly

protected information. A famous example occurred in World War II. The Germans kept tank production figures a secret, but they gave items like engine blocks sequential serial numbers. The Allies wanted to know exact tank production figures, so they solved the German tank problem by using statistical methods to analyze the distribution of these numbers on captured vehicles. They were able to predict tank production figures extremely accurately, to the point they predicted 270 tanks in a month when 276 were actually built. Thus, the secret information on tank production leaked.

Some systems require frequent password change, in an effort to limit danger from a password being discovered. However, people respond by choosing passwords in patterns, so it is easy to predict what subsequent passwords will be, given old ones, thus defeating the purpose of requiring frequent changes. Passwords Evolved: Authentication Guidance for the Modern Era

Although the comic title is "Predictive Models", the term Predictive modelling usually refers to computer programs that try to predict outcomes from data aggregation, such as reviewing health records to identify people most at risk from certain diseases based on weight, prior injuries, etc., before testing directly for the diseases themselves. This is similar to but not precisely like the example in the comic, since predictive text is using direct input to predict further input, while predictive modelling is using related input (such as make and model of a car along with driver acceleration patterns) to predict a different output (such as likelihood of a crash). Both

predictive text and predictive modelling could leak information as the comic suggests, however. Predictive text and the possibility to leak unintended information has been parodied on xkcd before in 1068: Swiftkey.

## #2170: Coordinate Precision

July 01, 2019

### WHAT THE NUMBER OF DIGITS IN YOUR COORDINATES MEANS

LAT/LON PRECISION	MEANING
28°N, 80°W	YOU'RE PROBABLY DOING SOMETHING SPACE-RELATED
28.5°N, 80.6°W	YOU'RE POINTING OUT A SPECIFIC CITY
28.52°N, 80.68°W	YOU'RE POINTING OUT A NEIGHBORHOOD
28.523°N, 80.683°W	YOU'RE POINTING OUT A SPECIFIC SUBURBAN CUL-DE-SAC
28.5234°N, 80.6830°W	YOU'RE POINTING TO A PARTICULAR CORNER OF A HOUSE
28.52345°N, 80.68309°W	YOU'RE POINTING TO A SPECIFIC PERSON IN A ROOM, BUT SINCE YOU DIDN'T INCLUDE DATUM INFORMATION, WE CAN'T TELL WHO
28.5234571°N, 80.6830941°W	YOU'RE POINTING TO WALDO ON A PAGE
28.523457182°N, 80.683094159°W	"HEY, CHECK OUT THIS SPECIFIC SAND GRAIN!"
28.523457182818284°N, 80.683094159265358°W	EITHER YOU'RE HANDING OUT RAW FLOATING POINT VARIABLES, OR YOU'VE BUILT A DATABASE TO TRACK INDIVIDUAL ATOMS. IN EITHER CASE, PLEASE STOP.

40 digits: You are optimistic about our understanding of the nature of distance itself.

## Explanation

This cartoon gives increasingly precise latitude and longitude coordinates for a location on the planet Earth. However, a given pair of coordinates covers a trapezoidal region of land, and thus leaves some ambiguity; therefore, greater precision requires an increasing count of decimal places in your coordinates. This comic uses this information to roughly identify how precise a given coordinate length might be.

The increasing precision of coordinates in this cartoon are similar to the increasing magnification in the short documentary "Powers of 10," which can be found [here](#). (Also parodied in 271: Powers of One).

The coordinates at 28.52345°N, 80.68309°W (in decimal degrees form; in geographic coordinate system form using degrees, minutes, and seconds, 28° 31' 24.4"N, 80° 40' 59.1"W) are pointing to the Rocket Garden at the Kennedy Space Center in Merritt Island, Florida —specifically, the tip of the Delta rocket.

The sixth entry in the table, with seven digits of precision, includes the caveat that, while your coordinates map to areas small enough on the Earth's surface to indicate pointing to a specific person in a room, "since you didn't include datum information, we can't tell who". This is a reference to the geodetic datum or geodetic system — different ways of dealing with the fact that the Earth is neither perfectly spherical nor

perfectly an oblate ellipsoid. The various datums do not make much difference at six digits of precision, but at seven, there is enough skew depending on which system is in use that the person in a room you are referring to with the coordinates is ambiguous. It is unstated, but the remaining lines in the table with ever-greater precision suffer from this same issue and are equally ambiguous without datum information.

The final entry, with seventeen digits of precision, suggests that either the user is referring to individual atoms in the much-larger-scale whole-Earth coordinate system, or (perhaps more likely) has not bothered to format the values from the GPS module for viewing in the software UI in any way whatsoever, resulting in a value that is meaninglessly precise because the measurement wasn't that accurate to begin with. See 2696: Precision vs Accuracy. Even if the value is accurate, locating individual atoms by coordinates is not actually useful in most cases, and the motions of multiple systems within our physical world (continental drift, subtle vibrations, Brownian motion, etc.) would render the precise value obsolete rather quickly.

For the decimal places past the 5th on the latitude, the digits given are actually the first part of the decimal expansion of the constant  $e$  (2.7182818284), while for the decimal places past the 5th on the longitude, the digits given are part of the decimal expansion of the constant  $\pi$  (3.14159265358) starting with the second digit (4).

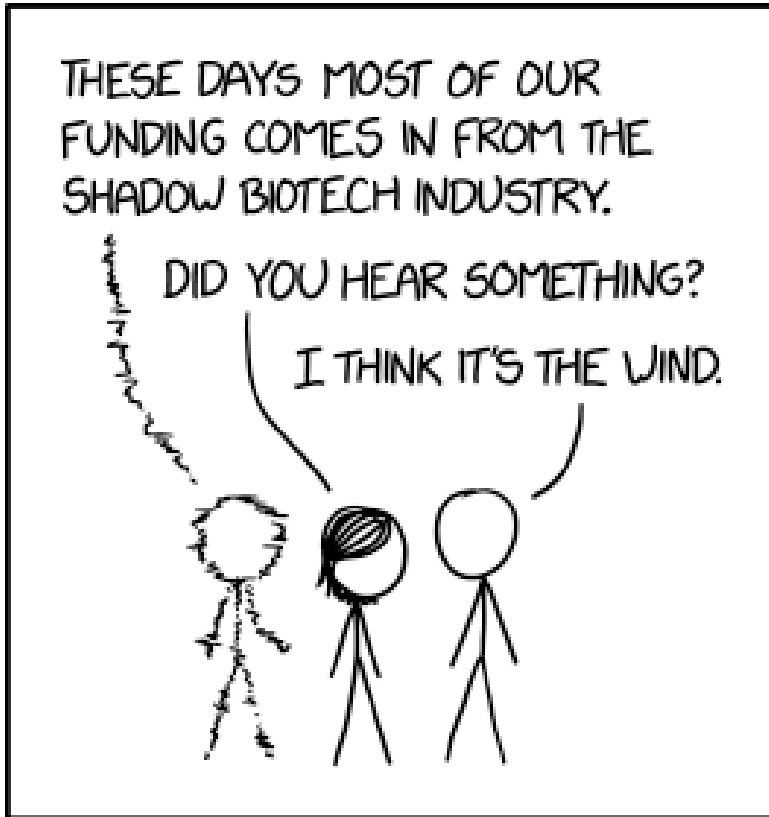
The title text references how at sufficiently small distances, our understanding of reality itself begins to break down. Smaller than the Planck length, which is more than a quintillion times smaller than the diameter of a proton, the ideals of Euclidean geometry no longer apply and space itself may be composed of a quantum foam where the very geometry of spacetime itself fluctuates, meaning coordinate systems based on an assumption that space doesn't change would no longer work. String theory, on the other hand, assumes that at a short enough distance the world is composed of ten space dimensions, which precludes the use of a two-dimensional coordinate system (not that our "normal" three dimensions don't do so in themselves).

The actual number of longitude digits needed to identify a point to a particular precision depends on its latitude. Near the poles, you need fewer longitude digits than at the equator – starting with one digit fewer at around lat.  $85^\circ$ , past all constantly inhabited human settlements, and with two digits fewer at lat.  $89.5^\circ$ , inaccessible to anyone but polar researchers and the occasional guided tour. The number of latitude digits for some particular accuracy stays essentially the same everywhere.



## #2171: Shadow Biosphere

*July 03, 2019*



THE SHADOW BIOSPHERE EXISTS,  
BUT IF YOU STUDY IT, YOU  
BECOME A SHADOW BIOLOGIST.

The typical Shadow Biology Department is housed in a building coated in a thin layer of desert varnish which renders it invisible to normal-world university staff.

## Explanation

A shadow biosphere is "a hypothetical microbial biosphere of Earth that uses radically different biochemical and molecular processes than currently known life. Although life on Earth is relatively well-studied, the shadow biosphere may still remain unnoticed because the exploration of the microbial world targets primarily the biochemistry of the macro-organisms."

Because organisms based on RNA would not have ribosomes, which are usually used to detect living microorganisms, they would be difficult to find in normal circumstances.

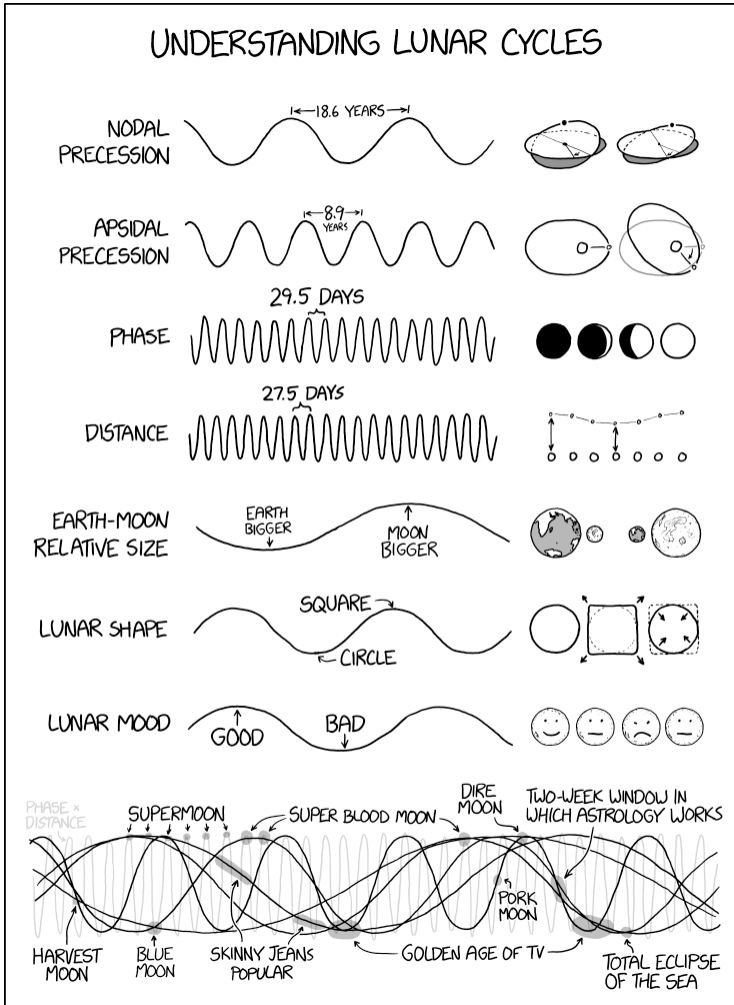
The comic suggests that this hypothetical biosphere exists, and its study is funded by "shadow biotech" corporations. The field would be called "shadow biology", so people that study it would be "shadow biologists". However, this is reinterpreted to mean "shadow" biologist, meaning that anyone that studies it becomes undetectable. A "shadowy" figure, presumably a shadow biologist, is telling this to Megan and Cueball, but they are not shadow biologists and can't hear him.

The title text references desert varnish, an orange-yellow to black coating found on exposed rock surfaces in arid environments, which has been suggested as a potential candidate for a shadow biosphere. Unless a building was made with already-varnished rocks, it would be impractical to cover a building in desert varnish (it forms

naturally on rocks over thousands of years). Ignoring its impracticality, the joke is that if a building were covered in desert varnish, it would supposedly be invisible to biologists who don't study the shadow biosphere.

# #2172: Lunar Cycles

July 05, 2019



The Antikythera mechanism had a whole set of gears specifically to track the cyclic popularity of skinny jeans and low-rise waists.

## Explanation

This comic shows a mixture of real, scientific lunar cycles and cycles that are comedic or fictional in nature. The first four cycles are factual, while the ones following them are not.

- Nodal precession: The Moon's orbital plane is tilted slightly compared to the Earth's orbital plane around the sun (the ecliptic). This tilt is why we don't constantly see eclipses; most of the time, the Moon's orbital plane is tilted higher or lower than the Sun, so they generally don't cross each other. The two points at which these planes do cross are called lunar nodes. Nodal precession is the gradual rotation of these nodes over time, a gyroscopic consequence of Earth's equatorial bulge. For the Moon this follows an 18.6 year cycle.
- Apisidal precession: All orbits have two points where the orbiting body is either closest to, or furthest away from, the thing they are orbiting. These points are called apsides, and the imaginary line between them is called the line of apsides. Apisidal precession is the gradual rotation of this line over time, which occurs in cycles of around 8.9 years for the Moon.
- Phase: Lunar phase describes the change in shape of the sunlit side of the Moon as viewed from the Earth's surface, which is caused by the changing angle between Moon and Sun as the Moon revolves around the Earth. The cycle of lunar phases takes 29.5 days, a figure

referred to as the synodic month.

- Distance: Because the Moon's orbit around the Earth is elliptical, its distance from the Earth varies slightly over the course of an orbit. This means that the moon's distance also follows a cycle which is the same as the length of one lunar orbit: approximately 27.5 days. This figure is referred to as the anomalistic month. Note that the synodic month is (perhaps counterintuitively) two days longer than the sidereal month — or to put it another way, it takes 2 more days for the Moon's phases to cycle than it does for the Moon to go around the Earth. This is due to the fact that the Earth is also moving around the Sun while the phases are going on, which means that the Moon has to spend 2 extra days "catching up" to the point at which the lunar phase cycle can restart.
- Earth-Moon relative size: This is a joke cycle; the Earth and Moon do not physically change size, nor does the Moon ever become larger than the Earth. This may be playing on the idea that the Moon often appears to change size to viewers on Earth, due to various factors; most commonly, this is due to the Moon illusion, which tricks the brain into perceiving the Moon as much larger than it really is. There are also so-called supermoons, which occur when the full moon coincides with the Moon's closest approach to Earth; these actually do increase the Moon's apparent size, although by a relatively insignificant amount.
- Lunar shape: Again, this is a joke cycle; the Moon does not actually change shape. A shape intermediate

between circle and square is known as a squircle, a subclass of the superellipse.

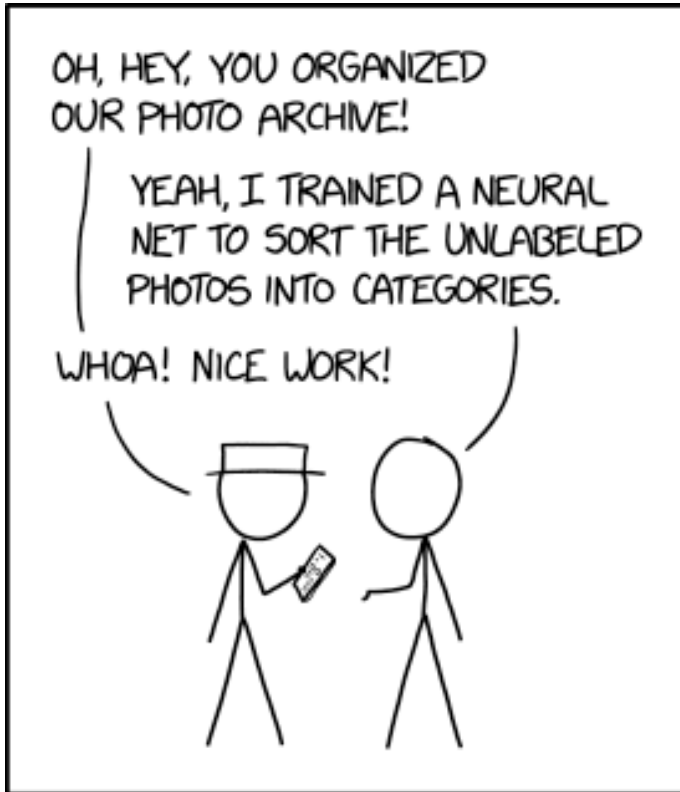
- Lunar mood: The moon does not have a mood, although humans can have moods that fluctuate over time, sometimes with a regularity akin to a cycle. Ironically, the section of the graph that shows a good (i.e. happy) mood has the graph line curving up then down like the mouth of a frown, and for the bad (unhappy) mood it curves down and then up, as in the mouth of a smile.
- The final diagram shows many different cycles superimposed on each other, highlighting areas where several cycles are coinciding. This is likely satirizing the media trend of overhyping astronomical coincidences and giving them grand-sounding names:

The Antikythera mechanism mentioned in the title text is an ancient Greek machine, rediscovered in 1901, designed to calculate astronomical positions. The title text jokes that there is a set of gears on said mechanism that is used to predict the popularity of "skinny jeans" and "low-rise waists." Since it was likely created in the 1st or 2nd century B.C., it is impossible for the creators to have had any knowledge of skinny jeans or low-rise waists - both are modern-day clothing fashions.[citation needed]

"Total eclipse of the sea" may also refer to the song "Total Eclipse of the Heart".

## #2173: Trained a Neural Net

July 08, 2019



ENGINEERING TIP:  
WHEN YOU DO A TASK BY HAND,  
YOU CAN TECHNICALLY SAY YOU  
TRAINED A NEURAL NET TO DO IT.

It also works for anything you teach someone else to do.  
"Oh yeah, I trained a pair of neural nets, Emily and Kevin,  
to respond to support tickets."



## Explanation

This is another one of Randall's Tips, this time an Engineering Tip.

An artificial neural network, also known as a neural net, is a computing system inspired by a human brain, which "learns" by considering lots and lots of examples to develop patterns. For example, these are used in image recognition - by analyzing thousands or millions of examples, the system is able to identify particular objects. Neural networks typically function with no prior knowledge, and are "trained" by feeding in examples of the thing that they are told to analyze.

Here, Cueball is telling White Hat how he trained a neural net to sort photos into categories. The joke in the comic, is the engineering tip from the caption. It states that since a human brain is already a neural network, albeit a biological one instead of an artificial one, then by teaching oneself (or others) to do a task, you are de facto training a neural network to do so. So instead of designing and training an artificial neural net that could do this task, all Cueball did was manually sort the photos into categories (although he could then use those sorted images to train an artificial neural network).

It is not advisable to say this in real life, because you might then be expected to use your already-trained neural net to do a similar task (or redo the same task) with much greater speed, thus ruining the facade.

However, presenting work done by humans as work done by machines has been done in real life, perhaps starting with the Mechanical Turk in 1770 and continuing into the present day by various AI-themed startups. For example, Engineer.ai described itself as using "natural language processing and decision trees" to automate app development, but was actually employing humans.

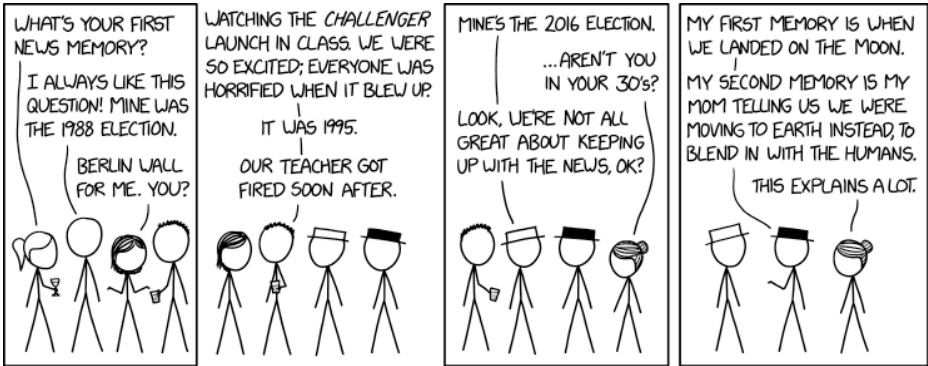
The title text is a continuation of this joke, as instead of designing and training two artificial neural nets named "Emily" and "Kevin", all he has done is train two people with those names to manually respond to support tickets. Again, doing this in real life is not advisable, as most people are offended when they are referred to by programmers as deterministic automata with no free will.[citation needed]

Neural networks have been trained to perform other tasks that are routine for humans, but formerly more difficult for computers, such as driving cars, playing games like chess, go, and Jeopardy!, and communication skills like extracting phonological information from speech as per Figure 1 here. In 1897: Self Driving, Randall suggested that crowdsourced applications like ReCAPTCHA, that have been used to train neural nets to recognize objects necessary for safe driving in photographs, may also be used for Wizard of Oz experiments. An example of such a Wizard of Oz experiment for phonological training as a form of peer learning has been explored, and related work is occurring on automating vocational training.

The extent to which computer neural nets are analogous to human neurobiology is a topic which fascinates the scientist and layperson alike. While there is no fully universal consensus on the matter, at least one apparently longstanding theoretical paradigm has received attention recently.

## #2174: First News Memory

July 10, 2019



Psychology researchers say our 'flashbulb' memories of big events can be unreliable, but I clearly remember watching live on **CNN** as **Challenger** crashed into and destroyed the **Berlin Wall**.

## Explanation

Seven xkcd characters are discussing their "first news memory", their first memory of an event that was reported by the news media. Typically, very young children are unaware of even major news events. At some period in childhood, a news event will be significant and widely covered enough that the child will notice and remember it. Which specific event this is impacted by the person's age, where they live, and how prominently the news is featured in their homes and surroundings.

In the first panel, Cueball and Megan report that they remember the 1988 US presidential election and the the removal of the Berlin wall in 1989 respectively. These are normal 'firsts' for Americans born in the early 1980s, as both of these events dominated media coverage at the time when people of that age would first be old enough to notice and remember it.

Hairy then recalls watching the Challenger explosion in school. A number of schools in the United States showed the footage of the Space Shuttle Challenger being launched, only to be shocked when the rocket exploded shortly after take-off. This would indeed have been a formative memory for the many students who saw it live, but Hairy subverts this expectation by clarifying that he saw it in 1995, nearly a decade after the explosion. He mentions that his teacher was fired soon after, presumably for deliberately exposing young students to a traumatic event without a good reason.

White Hat says that his first news memory was about the 2016 election (presumably the 2016 US presidential election), which is only three years prior to the publication date of this comic. As he is in his 30's the fact that he can't remember any earlier news events surprises his friends, as he apparently was entirely unaware of news events for most of his life.

The final memory comes from Black Hat, who says he remembers "when we landed on the moon". This implies that he's talking about the first moon landing, which occurred on July 20, 1969, and that "we" refers to the United States (which launched the mission in question). For people who were children in the 1960's, having the first moon landing as a memory is quite common.

Black Hat subverts this interpretation by saying 'my second memory is my mom telling us we were moving to Earth instead, to blend in with the humans.' This completely re-interprets his first sentence, as it suggests that the "we" refers to himself and his family actually landing on the moon. It also implies that he's an alien who landed on the moon as a stopping point before relocating to earth. Hairbun remarks that this revelation "explains a lot", implying that Black Hat's fundamental disregard for normal standards of human behavior make more sense if he is, in fact, not human. Of course, it's equally valid to conclude that Black Hat is simply lying to mess with the people around him, which would be fully in character for him. This could also mean that Black Hat and White Hat are brothers, and thus, since it is unclear when they landed, it's possible the election was

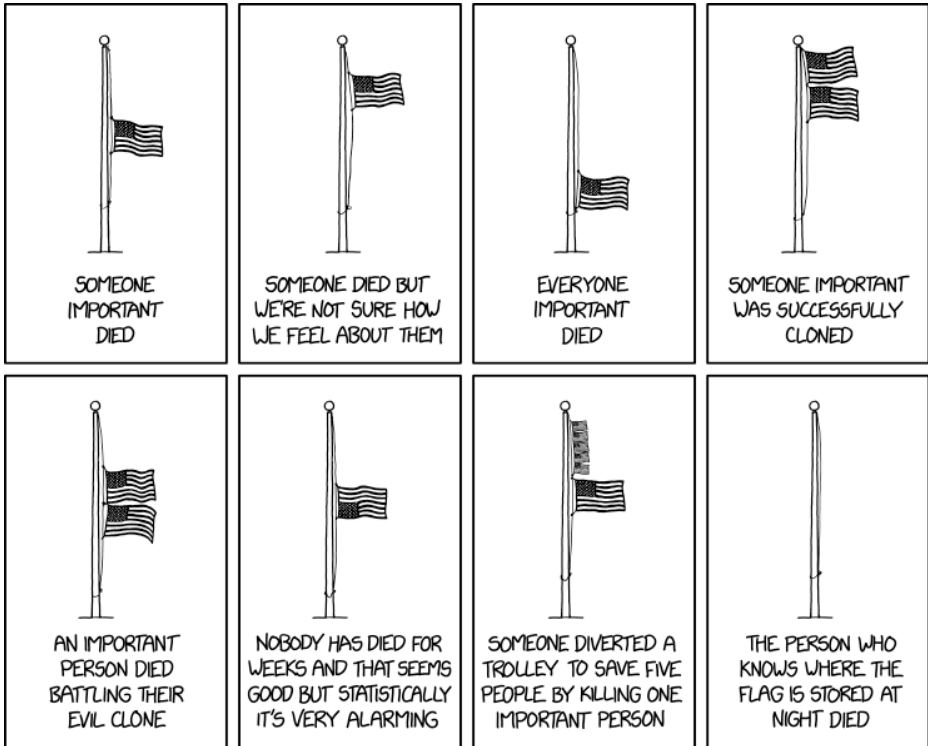
the first news episode White Hat ever watched.

### **Title Text[edit]**

The title text gives the claim that flashbulb memories of big events can be unreliable. Randall (or another character in the comic, possibly Hairbun or Black Hat, who would want to spread misinformation) denies this claim, claiming to remember watching on CNN as the Challenger spacecraft crashed into the Berlin Wall. This is an inaccurate memory of these two events, as the Challenger explosion occurred in 1986 over the Atlantic Ocean, just east of Cape Canaveral, Florida, and did not occur near the Berlin Wall (in Berlin, Germany). Also, the Berlin Wall was intentionally demolished starting in 1989; it was not damaged by a space shuttle.[citation needed] It is possible that this memory also conflates those events with those of the September 11 attacks since the latter did involve three winged craft crashing into and destroying landmark structures.

## #2175: Flag Interpretation

July 12, 2019



When Salvador Dal died, it took months to get all the flagpoles sufficiently melted.



## Explanation

In many countries including the United States (whose flag is depicted in the comic), it is customary to lower the flag to half staff when important public figures die. This is normally done by raising the flag to full height, then immediately "lowering" it to half height. In the US, regulations regarding flying the flag at half staff specify the length of time for the flag to be flown at half staff, and are based on the importance of the person who has died. There are no regulations where the flag would be flown at any height other than full height or half staff, and there are no regulations where multiple flags would be flown.

The definition of half-staff, or half-mast, differs between countries and does not necessarily imply flying the flag at half the height of the pole or mast. For example, in the USA the flag is usually flown at half the height of the pole, whereas UK practice is to leave space for an 'invisible flag' above the flown flag, which may mean flying the flag near the top of the pole depending on its height. These differing practices contribute to confusion and ambiguity concerning the flag height, which is exploited in the comic.

Randall, as usual, makes a humorous list of fictional additional traditions.

The title text is a reference to *The Persistence of Memory* and other paintings and sculptures by Salvador Dalí

which include watches and other objects that are melting.

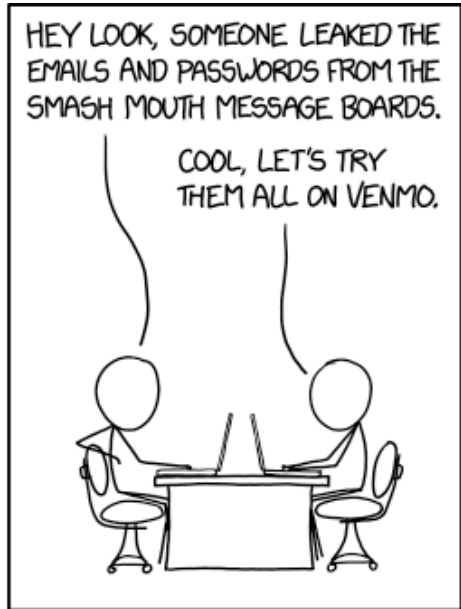
**Table**[\[edit\]](#)

## #2176: How Hacking Works

July 15, 2019



HOW PEOPLE THINK  
HACKING WORKS



HOW IT ACTUALLY WORKS

If only somebody had warned them that the world would roll them like this.

## Explanation

In similar spirit to 538: Security, this comic deals with how many people perceive hacking and security best practices, and how it differs from the actual reality. Specifically, the comic points out the flaw in the argument of some security-minded people that writing passwords down on a sheet of paper is a massive operational security vulnerability, not accounting for the threat model of the general public: reused passwords being leaked from seemingly benign places.

The first panel shows a group of masked men, who have apparently flown to the US from a different country and broken into someone's house. They find a book labeled "Passwords" that contains all the passwords of their target, and one reports this using a walkie-talkie, while another remarks that the target is a fool for writing down their passwords. While it is true that storing passwords on paper is generally a bad idea, one has to keep in mind the alternatives—password reuse or unencrypted password documents on a computer—that non-technical people might otherwise engage in. These are far easier to exploit for a casual attacker that goes for quantity over quality. In addition, given the larger group of potential attackers are the remote attackers, storing passwords on a piece of paper, while horrible for security from a local "in person" attacker, is actually pretty effective against a remote attacker being able to gather up your passwords.

The second panel goes into detail how such an attack is

usually executed: First, a database containing usernames/emails and associated passwords or insufficiently salted password hashes is stolen from an improperly secured website. Randall's example uses a fictional breach of a small forum dedicated to the band Smash Mouth, but even large companies are not immune to leaks. Assuming the passwords were not hashed, the crooks then go on and automatically try to log in to a popular payment service, Venmo, with the harvested credentials. Even though the success rate might be just fractions of a percent, due to the scale and cheapness of the attack (which can be automated, requiring no sustained effort from the crooks), it is likely still profitable. Such an attack has previously been discussed in 792: Password Reuse.

Although writing passwords on paper can allow users to create unique complex passwords without being limited by human memory, and therefore protect themselves from these sorts of mass-breach attacks, their passwords are now more vulnerable to insider attacks by e.g. family members, close friends, or co-workers.

The way recommended by most security experts to prevent these kinds of attacks is to use a password manager - a secure application that stores all of your passwords in an encrypted vault that only you can access. This way, you only need to remember one password - the master password to your vault - and all of your other passwords can be as long, different, and random as you like. This means that even if a crook manages to get one of your passwords, they won't be able to use it to access

any other sites, and so the attack shown in the comic would fail. Websites can also support two-factor authentication, where the user must supply a randomly changing code from a second device, such as a cell phone application or standalone keyfob, to log in.

The title text is referring to Smash Mouth's song "All Star," where the first line of the lyrics is "Somebody once told me the world is gonna roll me." The singer subsequently admits that he is not "the sharpest tool in the shed," which would be consistent with re-using simple passwords across multiple accounts (including financial accounts).

## #2177: Gastroenterology

July 17, 2019



"Mostly it means that I'm acutely aware that the kid one table over coughed as the server walked past with our food."

## Explanation

Gastroenterology is the study of the normal function and diseases of the digestive system: esophagus, stomach, small intestine, colon and rectum, pancreas, gallbladder, bile ducts and liver.

Antibiotics are substances that kill bacteria. They are effective at treating bacterial infections, including in the gut; unfortunately, they can also kill the normal gut bacteria. Probiotics are harmless or helpful bacteria which are sometimes used to replace the bacteria killed by an antibiotic. This reduces chances of re-infection by pathogens, and allows the natural gut microbiome to recover more effectively; comic 1471 was about the same theme. Probiotics are included in many foods, such as yogurt, as well as supplements, and are marketed as having health benefits.

The comic plays on the names probiotic and antibiotic. When matter and antimatter are mixed, they annihilate each-other, rapidly releasing energy (an explosion).

This comic imagines a similar process when probiotics and antibiotics are mixed: Ponytail and a nurse runs into a room, with someone chasing after them, leading the nurse to exclaim that “they’re right behind us.” Ponytail mixes the probiotics and antibiotics, and throws the jar like a grenade, before continuing to run with the nurse. The reaction between the probiotics and antibiotics causes the jar to explode, presumably killing the pursuer. In reality, antibiotics and probiotics are often used



simultaneously during treatment, but they are taken so that they do not mix (taken at different times or by different methods). Mixing them as in the comic, would just cause the antibiotic to kill the probiotic bacteria. Explosive reactions between antibiotics and probiotics are highly unlikely.[citation needed]

Matter and antimatter would react pretty much instantly upon mixing, not a short time later, as in the comic. (Also, one could not keep antimatter in a normal jar, or pour it in an atmosphere). The reaction shown is similar to the reaction between an acid and a base, or between a fuel and an oxidising agent. A judicious mix of substances (at a concentration low enough not to 'cook off' on contact) could cause an explosion after a short delay if kept in a tightly sealed container like a water bottle, or else start to build pressure that is temporarily held in check by that container, as in the explosion here. The skill of the individual constructing such a weapon would be to know how to make it effective enough without prematurely causing damage to themselves.

In the last panel, Ponytail is giving a more mundane summary of what gastroenterology is like (lots of paperwork). This is similar to Indiana Jones saying that archaeology is boring. The explosion sequence might be:

- Ponytail's action fantasy of what the job could be.
- Megan's fantasy, and Ponytail is telling her what it is actually like.
- Real, and Ponytail is covering it up.

In the title text, Ponytail adds that her work makes her aware of a child coughing as the server was bringing food at the restaurant table, exposing the food to possible germs that could cause a gastrointestinal infection.

## #2178: Expiration Date High Score

July 19, 2019

WHAT'S THE MOST EXPIRED ITEM  
YOU'VE FOUND IN YOUR HOUSE?  
CALCULATE YOUR  
EXPIRATION DATE HIGH SCORE  
(MUST BE SOMETHING YOU PURCHASED)

$$\text{SCORE} = \frac{(\text{YEAR YOU FOUND ITEM}) - (\text{YEAR ITEM EXPIRED})}{(\text{YOUR AGE WHEN YOU FOUND IT})} \times 100$$

THESE BEANS EXPIRED IN 2010! THAT'S...  
LET'S SEE... 24.3! NEW PERSONAL BEST.

YOU'RE NEVER GOING TO BEAT YOUR  
MOM'S JAR OF PICKLES FROM 1978.

MAYBE THERE ARE MORE CANS IN THERE.  
REMINDE ME NOT TO LOOK UNTIL 2030.

THIS IS THE WORST COMPETITION.



"Wait, we've **MOVED** since 2010. How on Earth did--" "Look, some of us were just born to be champions."

## Explanation

Randall is introducing the rules of the game Expiration Date High Score, hence the title.

If you find an item which you purchased, but is now past its expiration date, you get a score which is what percent of your lifetime elapsed between when the item expired and when you found it.

Megan, looking in a cupboard, find a can of beans that expired in 2010 (9 years ago), and that gives her a score of 24.3. Megan's age is thus revealed to be 37, found by substituting 2019 and 2010 into the formula  $100 \cdot (2019 - 2010) / \text{age} = 24.3$  and solving for the age. This is consistent with 630: Time Travel, in which Megan's date of birth is given as 1983.

Cueball then remarks that she will never beat her mom's jar of pickles that was from 1978. Megan then wonders if there are more cans (from 2010 or before) in the cupboard, and asks Cueball to remind her to not look any further until 2030. At that time the can would have been 20 years old and she would be 48, giving such a can a score of  $100 \cdot (2030 - 2010) / 48 = 41.6$ . That would thus beat her mom's high score.

If her mom's jar had expired in 1978 (not clear from the text), and for instance was found last year in 2018, then the formula for the mother's score would be  $100 \cdot (2018 - 1978) / \text{Mom's age}$ . And this should then

not be more than 41, thus revealing the mother age to be around 100 years old today (98 last year). Of course the jar could have had an expiration day some years later, or have been found earlier. Otherwise Megan's mom would have been above 60 when giving birth to Megan. Of course Megan could also just take this extra long wait in case the next can is not from 2010 but only 2013 etc.

Cueball's final remark is that this is a terrible competition, the worst ever. Because keeping food that can spoil could potentially be dangerous, if not so, at least disgusting when finally trying to get rid of it later.

Many perishable items, such as food, cosmetics, medications, batteries, or condoms, have expiration dates, or sometimes best by dates. The only other rule is, that it has to be something you have purchased yourself, so that heritages or stuff that was left in the basement when one moved in, does not count. A score of 100 or higher would indicate the item expired when you were born or before you were born, meaning it was already expired when you purchased it.

The joke is, that owning expired items without noticing for a long time, is here getting you a high score, while in reality it is not considered favorable to have food that has expired long time ago.[citation needed]

The other joke is both the items in the comic (a can of beans and a jar of pickles) do not go bad with time but in fact remain edible indefinitely (as long as the jar/can is not opened and is undamaged.)

Food going bad, in the sense that it will make you sick if you eat it, is most often caused by harmful bacteria growing in the food. Less often caused by fungi or yeast growing in the food and creating a poisonous substance, like methanol (wood alcohol.) The process of canning food involves boiling it to kill all possible pathogens, then sealing it in a jar/can while the food is still hot, with no air bubble. As long as this process is done correctly, the jar lid will have an airtight seal, so as long as the can is not punctured, or does not have a hole become rusted through, no bacteria/virus/yeast/fungi can get in and the food cannot spoil. Some food may discolor over time in the jar/can, or the texture may change, but it cannot go bad in a way that makes it unsafe to eat.

Megan's mom could not have a jar of pickles with a 1978 expiration date because in 1978 jars and cans of food did not have expiration dates. Since then many countries introduced laws and regulations requiring companies to put expiration dates on perishable goods. In some instances this can have the negative effect of people throwing out good food by blindly following the suggested expiration date. This behavior can incentivize companies to adjust the expiration date, or put expiration dates on non-perishable goods, so that people will re-buy the products sooner.

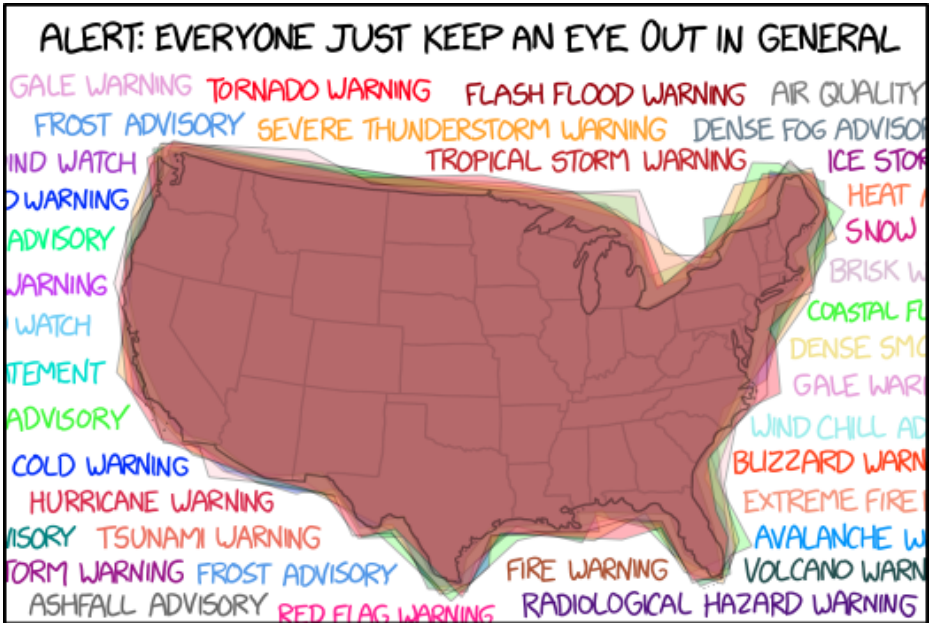
The title text continues the conversation from the comic. Cueball remarks that they moved since 2010... Thus the beans were apparently bought while living in a different home, meaning they were moved along with their other belongings. This is somewhat unusual as many people

take moving as an opportunity to go through their old stuff and get rid of things they no longer need. Since the rules clearly states that you have to have bought it yourself, it could not have been in the house when they moved in, they had to have brought it along (unless they later bought something that was already expired). But given Megan's final answer that "some of us were just born to be champions" indicates that she did bring it along, anticipating this game, and thus given her self a great score. And as is clear she is willing to wait 11 years to try to beat her mom's score.

It is not clear why they are keeping items for long periods of time in order to win. An easier way to win this game would be to buy food that is already expired. One could obtain a score of 100 simply by buying something that expired when one was born, and finding it the next year.

## #2179: NWS Warnings

July 22, 2019



WHEN THE NATIONAL WEATHER SERVICE NEEDS TO  
TAKE A DAY OFF, THEY JUST ISSUE WARNINGS FOR  
EVERYTHING SO NO ONE IS CAUGHT BY SURPRISE.

Kind of rude of them to simultaneously issue an  
EVACUATION - IMMEDIATE alert, a SHELTER IN PLACE alert,  
and a 911 TELEPHONE OUTAGE alert.



## Explanation

The National Weather Service (NWS) is a United States federal agency that is tasked with issuing national weather forecasts and extreme weather alerts.

This comic portrays the NWS as a person that needs breaks, which is absurd, as it is an important service and would probably always have staff active, even on holidays. For example, the NWS continued to work during federal government shutdowns, as it was considered an essential service for the protection of life and property. Even if one of the NWS's 122 local weather offices were to be incapacitated, contingency plans are in place to ensure that nearby offices act as emergency cover; as happened in March 2019 with flooding in Nebraska forcing the NWS office in Valley to evacuate.

Regardless, in this comic the NWS has decided to take a break, and so has opted to issue every extreme weather alert possible for the entire contiguous portion of the United States (including DC, but not Alaska or Hawaii) to make sure no one is caught by surprise by extreme weather, since the NWS will not be able to issue warnings. As the NWS could not be sure which areas will need to get warned of severe incidents, the NWS has decided to issue warning polygons that cover the entire United States (ostensibly except Alaska and Hawaii). A layer of humor is that this would necessitate warnings where they would be highly unlikely to occur in real life;

examples include issuing blizzard warnings for Florida, where any amount of snow is rare, and tsunami warnings for areas very far from any ocean coastline. The large quantity of implausible warnings would also most likely cause people to ignore all of them, defeating the purpose of issuing the warnings in the first place.

Each of the text warnings within the map are coloured, which matches the NWS color coding used for a given warning event.

The title text mentions how some of the warnings that have been issued require action to get to safety that contradicts the other warnings, for example, an evacuation warning and a shelter in place order, since doing one would mean failing to do the other. This confusing scenario would likely prompt many concerned citizens to call emergency services for clarification, but the 911 outage alert would advise against this, adding another layer to the absurdity of the occurrence of the NWS taking a break. A similar contradiction is present in 2841: Sign Combo.

This comic was likely inspired by the heat wave that impacted two-thirds of the US for more than a week.

NWS and tornado warnings was later mentioned in the title text of 2219: Earthquake Early Warnings.

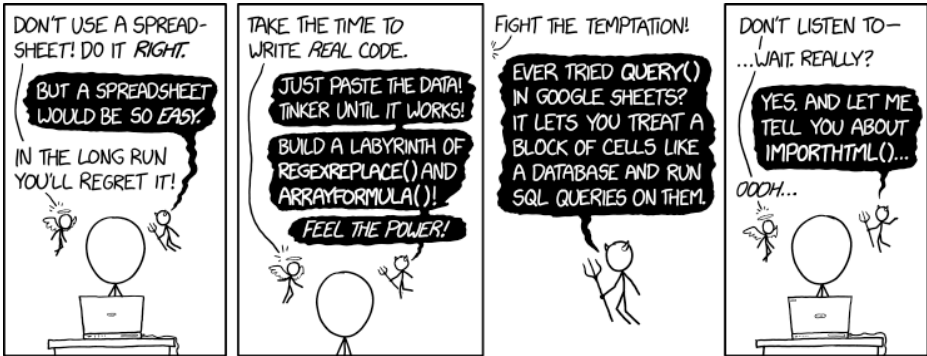
### **Table of warnings[edit]**

Assumptions about text outside of the frame are given in square brackets. This page from the NWS lists all the warnings and

colors, including all the hex codes for them which we stole referenced.

## #2180: Spreadsheets

July 24, 2019



My brother once asked me if there was a function to produce a calendar grid from a list of dates in Google Sheets. I replied with a single-cell formula that took in a list of dates and outputted a calendar. It used `SEQUENCE()`, `REGEXMATCH()`, and a double-nested `ARRAYFORMULA()`, and it locked up the browser for 15 seconds every time it ran. I think he learned a lot about asking me things.

## Explanation

Cueball is doing some task on his computer, with an angel and devil on either side of him, trying to influence his work. The angel is telling him to do things the "right" way, while the devil is telling him to do his work using a spreadsheet, which is considered by professional software engineers to be a shortcut or a hack.

Spreadsheets provide an array of cells, which can contain information or instructions. Spreadsheets are a common end-user development tool, allowing non-developers to easily create code. However they can be hard to maintain, thus they are often mocked by developers as a wrong approach to programming. Although it is not clear from the cartoon that this is meant, the "right" alternative to using a spreadsheet for some tasks may involve a database or a more general programming language.

The punch line comes when the angel becomes so intrigued by the spreadsheet functions, Google Sheets in particular, that it gives up trying to dissuade Cueball, and asks for more information from the devil.

In the title text, Randall mentions a time when he created a calendar grid in Google Sheets using a list of dates. This is described as being done in a "single-cell formula", and taking a long time to run. This shows the power and complexity of spreadsheets. The procedure taking a long time to run, and freezing up the internet browser

(possibly even the rest of the computer) for 15 seconds every time it ran, was probably not what Randall's brother had in mind when he requested help. His brother learned he might need to be wary about what he gets back when asking Randall for assistance.

All functions mentioned in this comic can be found in Google Sheets, but functions similar to some of them can be found in most modern spreadsheet applications.

`REGEXREPLACE(text, regular_expression, replacement)`  $\Rightarrow$  Replaces part of a text string with a different text string using regular expressions.

`ARRAYFORMULA(array_formula)`  $\Rightarrow$  Enables the display of values returned from an array formula into multiple rows and/or columns and the use of non-array functions with arrays.

`QUERY(data, query, [headers])`  $\Rightarrow$  Runs a Google Visualization API Query Language query across data.

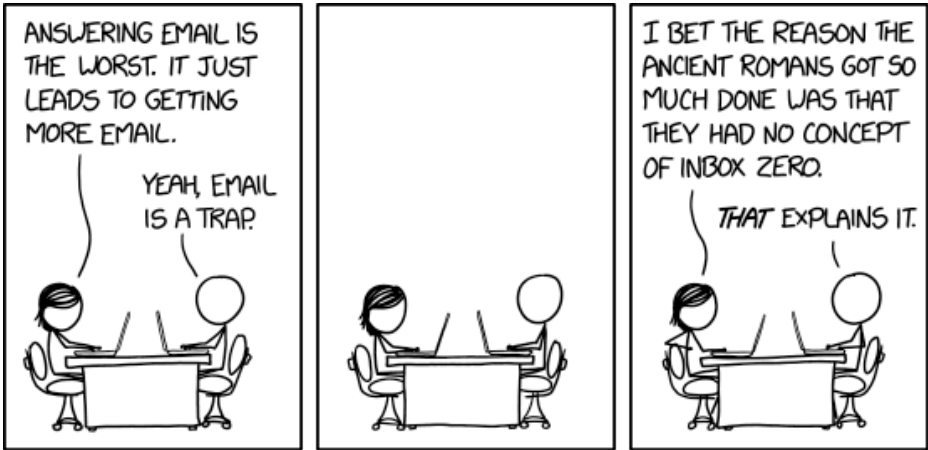
`IMPORTHTML(url, query, index)`  $\Rightarrow$  Imports data from a table or list within an HTML page.

`SEQUENCE(rows, columns, start, step)`  $\Rightarrow$  Returns an array of sequential numbers, such as 1, 2, 3, 4.

`REGEXMATCH(text, regular_expression)`  $\Rightarrow$  Whether a piece of text matches a regular expression.

## #2181: Inbox

July 26, 2019



Rome's declaration of war against Carthage was sent from a no-reply address, so Hannibal had to cross the Alps to deliver his "UNSUBSCRIBE" response in person.

## Explanation

Email differs from "snail" mail, in that people often expect a prompt reply. Replying to an email may lead to another email response, thus leading to a "loop" of constant replies and responses. Since an individual email is quick and cheap to send, people send lots of them. Thus people get a lot of emails, and may spend a large portion of their day dealing with email.

Megan observes that maybe the Romans got a lot done because they did not spend time on email. In doing this she plays on the email handling strategy named Inbox Zero, which they might not have had because the Roman number system had no symbol for zero. This is of course redundant, as email did not exist at the time.[citation needed]

Inbox Zero is an approach to email inbox management espoused by Merlin Mann, with the idea that people should spend as little time as possible in their email inbox. To achieve this, one should check one's inbox as few times as practical, and quickly deal with all new emails by deleting, delegating, sending a short reply where possible or categorizing them for later tasks. Basically it's a continuation of the "touch it once" strategy for dealing with physical mail.

The ancient Romans are one of the model historical societies, well revered for their culture and life. A common misconception is that Romans did not have a



concept of the number zero. The Romans were aware of the concept of zero, but there is no numeral for 0 in the Roman numeral system, as Roman numerals do not have place values like Arabic numerals. A value of ten or greater is represented in Arabic numerals using 0 as a placeholder for empty place values. Roman numerals do not have such a placeholder digit, and so did not have a numeral for zero; the word *nulla* was used to refer to "zero" in the sense of "nothing". Various sources indicate that this eventually gave use to N as a Roman numeral for "zero", and such is the case for modern users of Roman numerals.

The title text refers to Hannibal's crossing of the Alps, a famous military campaign by Hannibal against the Romans. Randall claims that Hannibal needed to invade Rome to tell them to stop sending him so many emails. The reason for this was that Rome's email was sent from a "no-reply" email address, so Hannibal had no way of replying by email, and had to tell them in person. The real reason for Hannibal to cross the Alps was because he wanted to conquer Rome. He did not conquer Rome, so he never sent his "unsubscribe" message.

## #2182: When I'm Back at a Keyboard

July 29, 2019



I SAY THIS A LOT FOR SOMEONE WHO  
ROUTINELY TYPES THOUSANDS OF WORDS  
IN TEXT MESSAGE CONVERSATIONS WHEN  
SOMEONE BRINGS UP *JURASSIC PARK*.

[after typing 1,500 words on feathered dinosaurs, paleontology, sexism, lava, and dinosaurs as animals rather than movie monsters] Sorry to cut it short, I'm on my phone. When I'm back at a keyboard, I can give you another

5,000 words.

## Explanation

Cueball is texting someone on his phone. However, since with a full sized physical keyboard you can type with all of your fingers, which is usually a much faster and more accurate way than using an on-screen keyboard on a smartphone, Cueball cuts off the conversation and says he will get back to whoever he was talking to when he can type on an actual keyboard, presumably at home and on his computer. While there are multiple techniques for making a smartphone increasingly easier to enter words into using its on-screen virtual keyboard, such as keyboard swiping, on-the-fly spelling and grammar checkers, and voice recognition to minimize using the keyboard at all, the combination of a full-sized keyboard along with a generous sized screen is hard to beat for speed and accuracy when typing larger blocks of text.

The joke is that despite claiming to be more proficient with a physical keyboard, rather than a digital one, Randall still goes into long rants through messages on his smartphone, whenever anybody brings up Jurassic Park.

There might also be a reference on Dennis Nedry, a character from the first Jurassic Park film. The programmer is responsible for a security sabotage and intends to be away from his keyboard only for a short while, but dies (not altogether) unexpectedly, worsening the situation in the park.

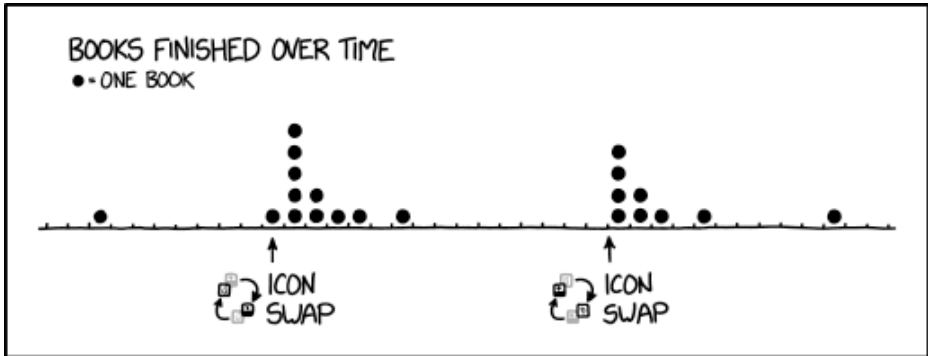
The title text shows a typical sentence from Randall after

having been in a chat over his phone. Before the sentence he has written 1500 words on his phone, all related to Jurassic Park, more or less. When he finally have written his fingers off he then says that he will have to stop now but once back at a keyboard, and even though he just typed 1500 words on his phone, he is ready to type even more (5000 words) using his keyboard.

The widespread uptake of mobile devices has stark implications for user-generated content sites on the internet. According to a 2014 New York Times article, only one percent of the changes to Wikipedia articles were made via mobile devices, although they displayed about a third of all Wikipedia page views that year.

## #2183: Icon Swap

July 31, 2019



I'M NOT SAYING I HAVE A PROBLEM COMPULSIVELY CHECKING NEWS AND SOCIAL MEDIA ON MY PHONE, BUT WHEN I REPLACE THE SOCIAL MEDIA APP ICON WITH MY EBOOK READER, I READ A HALF-DOZEN BOOKS BEFORE I GET USED TO THE CHANGE.

Someone's probably working on an eBook app where, if you stop reading right before some plot twist happens, the app will wait a while and then send you a breaking news alert about what's happening, prompting you to open it and read the next few pages to learn more.

## Explanation

Randall denies having a social media addiction. However, he concludes that he must have some problem, as he opens his social media / news apps many times a day. He tries to remedy this addiction by rearranging the icons on his phone's app launcher. Specifically, he swaps the app icon with that of an eBook reader, so opening the "social media app" would lead to the eBook reader, and vice versa. In this case, when he swaps a social media/news app with his E-book reading app, he ends up reading more books (as shown by the graph) because he is used to having his media app in its place, and is opening it up through muscle memory.

This results in the punch line, where he says that this causes him to read "a half-dozen" books before his muscle memory adjusts and not he stops opening his reader as often. Presumably, he changes the icons again in order to trick his muscle memory when he makes a conscious decision to read more books or use less social media.

Alternatively, Randall does not realize that he is reading books instead of a social media feed, and often gets through many books before realizing.

In the title text, Randall says that there is probably an eBook app in development that will use "breaking news alerts", typically sent as push notifications, about what is happening in the book, to prompt readers to continue reading more pages. This parallels how a news app works,

which would send an alert when a new event occurs.

This topic is similar to one he went over in 477: Typewriter, where he is compulsively trying to check news websites despite using a typewriter.



## #2184: Unpopular Opinions

August 02, 2019

UNPOPULAR *POSITIVE* OPINION CHALLENGE:

NAME A MOVIE THAT...

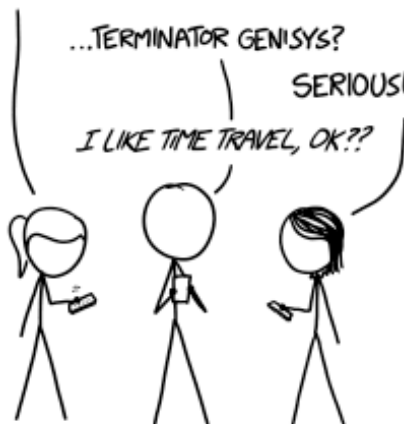
- (1) YOU GENUINELY LIKE (NOT "SO BAD IT'S GOOD")
- (2) CAME OUT IN YOUR ADULT LIFE POST-2000, AND
- (3) IS RATED BELOW 50% ON ROTTEN TOMATOES.

WOW, THIS IS HARDER  
THAN I THOUGHT.

...TERMINATOR GENISYS?

SERIOUSLY?!

I LIKE TIME TRAVEL, OK??



WHEN PEOPLE TALK ABOUT THEIR "UNPOPULAR OPINIONS" ABOUT MOVIES, THEY USUALLY MEAN HATING SOMETHING EVERYONE LIKES, BUT LIKING SOMETHING EVERYONE HATES IS MUCH HARDER.

I wasn't a big fan of *3* or *Salvation*, so I'm trying to resist getting my hopes up too much for *Dark Fate*, but it's hard. I'm just a sucker for humans and robots traveling through time to try to drive trucks into each other,

apparently.

## Explanation

Everybody has their own preferences as to what movies they like and dislike, and when your like or dislike of a movie seems to be different than the majority of people, you could call your preference the "unpopular opinion" because your opinion is the less prevalent one. This often takes the form of "I hate this movie and I don't understand why everybody else seems to like it", but this comic is talking about the opposite form, which it categorizes as less common, namely "I like this movie and don't understand why everybody else seems to hate it." The comic points out that it's relatively common to hate movies others appear to like, but the converse, in which you like a movie others seem to hate, is much harder to find. One explanation for this may be that if a movie is already established to be bad, you won't end up watching it anyway.

To illustrate how hard it is to like a movie everyone else seems to dislike, the comic presents a challenge whereby you 1) identify a movie you definitely like, which 2) came out during your adult life (so it isn't tainted by childhood nostalgia), and which 3) the majority of other people don't like, as measured informally by having a popularity rating below 50% on the Rotten Tomatoes website (a website that aggregates reviews of films). Supposedly you will find it hard to find a movie that meets all three criteria. The rules prohibit a movie that the viewer finds "So Bad, It's Good" - the enjoyment of the movie must be genuine, for its positive qualities, rather than ironic

enjoyment of its negative qualities.

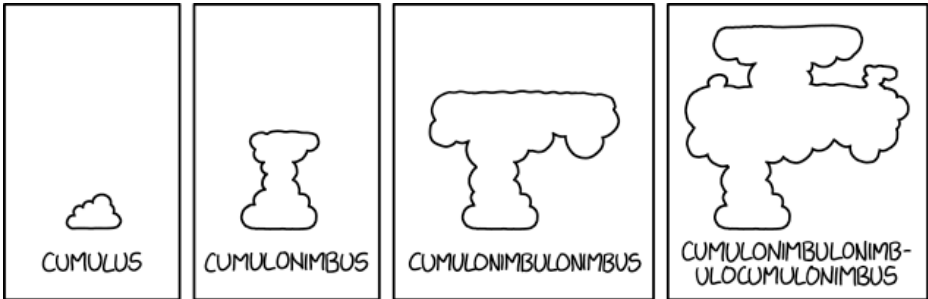
The image in this comic gives an example of this effect, namely the movie Terminator Genisys, the fifth in the Terminator series, released in 2015. This series, about time-traveling killer robots, included the highly rated Terminator 2 (93% on Rotten Tomatoes), while Terminator Genisys is only 26%.

The title text refers to three movies in the Terminator franchise, Terminator 3: Rise of the Machines (2003), Terminator Salvation (2009), and Terminator: Dark Fate (due out later in 2019). The Terminator movie series has featured both time travel and trucks driving or attempting to drive into people, and Randall apparently finds himself drawn to such movies. He hopes that Dark Fate will be a good movie, but has low expectations, considering the less than stellar ratings of the last 3 movies (69%, 33%, and 26%).

A Rotten Tomatoes search ordered by release date limited to qualifying movies (except that it goes up to 60%) can help individuals verify the difficulty of finding such movies for themselves.

## #2185: Cumulonimbus

*August 05, 2019*



The rarest of all clouds is the altocumulenticulostratonimbulocirruslenticulomammano ctilucent cloud, caused by an interaction between warm moist air, cool dry air, cold slippery air, cursed air, and a cloud of nanobots.

## Explanation

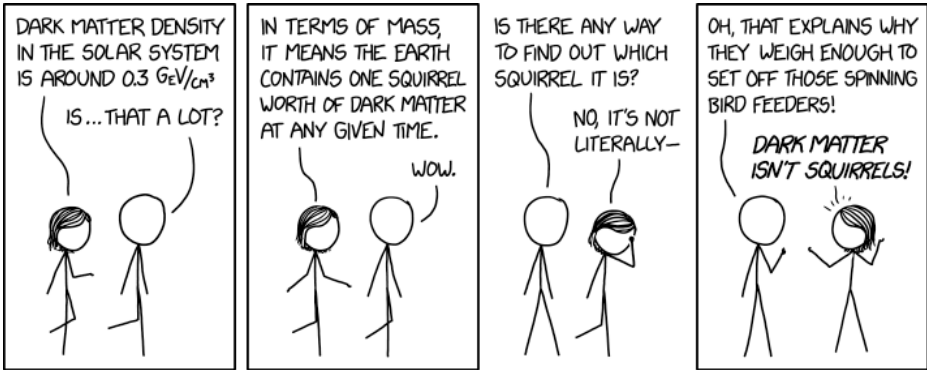
This comic follows the naming of clouds. As with other lists (like in 1874, 2022, 2497, 2687 and 2954), it starts off as normal but then gets more unusual until it is unrealistic.

The International Cloud Atlas defines the cloud types that are recognized by the WMO, the World Meteorological Organization. It was first published in 1896. Similarly, IUPAC publishes a manual that allows chemists to name chemical compounds in a consistent manner.

The Altocumulenticulostratonimbulocirruslenticulomamma noctilucent may thus be a pun on IUPAC, which (theoretically) offers a unique name for each possible strand of DNA and other complex molecules (such as Titin). Therefore, Randall might have seen a unique cloud that has never been observed before, but yet, thanks to IUPAC-like cloud naming rules, he came up with a "valid" name for his observation.

## #2186: Dark Matter

August 07, 2019



To detect dark matter, we just need to build a bird feeder that spins two squirrels around the rim in opposite directions at relativistic speeds and collides them together.

## Explanation

Megan and Cueball are talking about dark matter, the mysterious invisible mass observed indirectly by the rate at which galaxies rotate. Megan states that dark matter's density in the solar system is  $0.3 \text{ GeV/cm}^3$ , as claimed, for example, by Bovy and Tremaine (2012) "On the local dark matter density" in *The Astrophysical Journal*. Cueball does not understand what that means, so Megan explains that it equates to one squirrel's mass of dark matter in the volume of the Earth. In the final two panels, Cueball humorously misinterprets this as implying dark matter is actually one or more squirrels, and thereby provides the mass which causes squirrels to spin on bird feeders designed to deter them while birds, with lower mass, do not. This enrages Megan.

The gigaelectronvolt (GeV) is a unit of energy that can be converted to a mass using Einstein's formula  $E = mc^2$ . It is typically used for subatomic particles, such as weakly interacting massive particles (WIMPs), one of several contending possibilities for the still-open question of the composition of dark matter, and one which Megan's uniform density figure implies constitutes most of it. For example, the mass of a proton is  $0.938 \text{ GeV}/c^2$ . However, it is common to omit the  $c^2$  denominator, representing masses as GeV or MeV. A mass represented as  $0.3 \text{ GeV}$  is equal to  $5.35 \times 10^{-25}$  grams. Since the Earth's volume is  $1.083 \times 10^{27} \text{ cm}^3$  Megan's figures imply that a squirrel has a mass of about 1.3 lb ( $1.083 \times 5.35 \times 10^{27-25} \text{ g} = 580 \text{ g}$ ), a typical weight for



several species of common squirrels.

Squirrels are a recurring topic on xkcd, but are not a serious alternative to WIMPs as a scientific explanation for the composition of dark matter. Since the September 2015 detection by the Laser Interferometer Gravitational-Wave Observatory (LIGO) and subsequent confirmation by the Virgo interferometer of gravitational waves from unexpectedly many merging black holes substantially more massive than those produced by stellar collapse, primordial black holes (PBHs) have become a popular alternative explanation to WIMPs (or squirrels), attracting proponents at NASA, and other cosmologists for several reasons. But PBHs remain controversial, because if they constituted more than a very small portion of dark matter, alternative explanations would be almost entirely excluded.

Other alternative hypotheses for the observations suggesting dark matter, such as theories involving the gravitational force varying over different distances, often upset cosmologists as much as Megan is shown to be, because they violate the cosmological principle among other issues. Part of this frustration may be due to the fact that even after many decades of careful, tremendously expensive, and often stunningly beautiful experiments, none of the many explanations for dark matter or the observations suggesting it have as yet any support from direct empirical observations.

To help resolve this mystery, the title text imagines using a spinning bird feeder like a particle accelerator, colliding

squirrels at relativistic speeds as if they were subatomic particles, to detect dark matter particles like the CERN accelerator discovered the Higgs boson. (Note, however, that accelerating even one squirrel to relativistic velocities would destroy the feeder along with any nearby birds, not to mention the squirrels, and the surrounding city.)

## #2187: Geologic Time

August 09, 2019

IMAGINE EARTH'S HISTORY AS A FOOTBALL FIELD, FROM THE PLANET'S FORMATION AT ONE END TO TODAY AT THE OTHER.

COMPLEX LIFE WOULD BE LARGELY LIMITED TO THE FINAL TEN YARDS. DINOSAURS APPEAR AT THE FIVE-YARD LINE, THE AGE OF MAMMALS HAPPENS IN THE LAST  $1\frac{1}{2}$  YARDS, AND HUMANS ARISE IN THE FINAL FEW MILLIMETERS.

ALL OF WRITTEN HISTORY WOULD FIT IN A STRIP NARROWER THAN A SINGLE HAIR.

"TWO WEEKS" WOULD BE TOO SMALL TO SEE EVEN WITH A POWERFUL MICROSCOPE.



GEOLOGISTS ALWAYS TRY THIS WHEN THEY'RE LATE TURNING SOMETHING IN.

Ok, well, we'll be sure to pay you sometime soon, geologically speaking.

## Explanation

Analogies to explain the passage of billions of years are often used in popular science explanations, to help compress these huge spans of time into something the human mind can comprehend; the football field analogy is one such analogy. The Earth is approximately 4.54 billion years old; if you were to present a timeline of Earth as long as a gridiron football field (100 yards or 91 meters), then each inch of that length would comprise more than 1.26 million years of Earth's history and each millimeter nearly 50,000 years.

- Complex life refers to the various animal species which arose in the Cambrian explosion 541 million years ago; the length of time that complex life has existed would translate to 11.9 yards on the football field.
- Dinosaurs are estimated to have first evolved as early as 244 million years ago, and survived until the Cretaceous–Paleogene extinction event 66 million years ago; thus it would begin at the 5.37-yard mark and continue up to the 1.45-yard mark.
- Although the evolution of mammals can be dated to around 220 million years ago (depending on definition), they didn't truly become dominant until the aforementioned extinction event paved the way for them to grow and diversify 66 million years ago. The age of mammals therefore extends from the 1.45-yard mark to the goal line (present day).
- Homo sapiens is estimated to be 350,000 years old; our

species takes up only a meager 0.28 inches on the football field, or 7.1 millimeters.

- The Holocene era, or the age in which humanity rapidly grew to dominate the Earth, is even less geologically significant, having lasted about 11,650 years so far, which translates about 0.234 millimeters.
- Recorded history begins with accounts dating back to roughly 3500 B.C.E., about 5500 years ago as of this comic's publish date; it would take up a width of about 111 micrometers. A human hair can be as thin as 17 micrometers, or as thick as 181 micrometers, so Megan's claim that all of human history can fit within the width of a human hair depends largely upon the sample being used.

Megan, a geologist, tells a story about how small the timespan of human history is compared to Earth's total history. She does this to juxtapose it with normal human time-scales, to imply that her being two weeks late turning in her project is immaterial by the standards of the Earth's tremendous age. She tries to sell this story to Cueball and Hairbun, but Hairbun's response does not seem to bode well for Megan.

Megan's delay of two weeks would map to about eight nanometers on the football field. The most powerful electron microscopes have a magnification of ten million, which would make it look like about eight centimeters (about three inches), so her statement about it being "too small to see even with a powerful microscope" is a bit of an exaggeration. The most powerful optical microscope

has 6500x magnification (New York Times, March 8, 2011), which would indeed be inadequate.

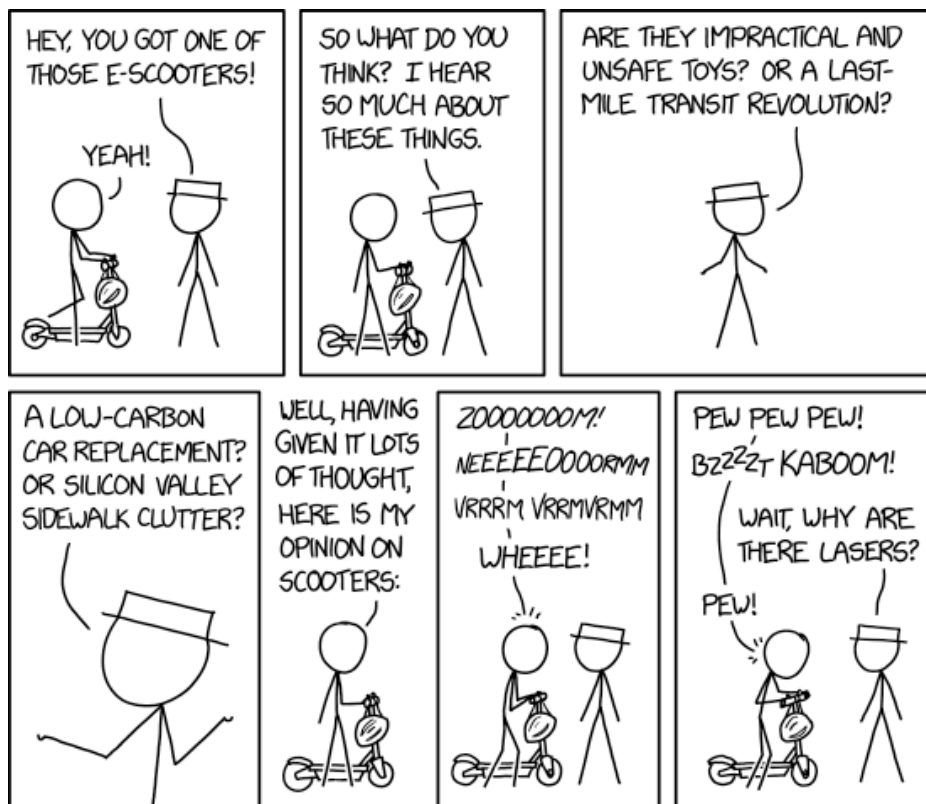
Randall states in the caption that this is a trick that geologists always try to use when being late turning something in.

In the title text, Hairbun and Cueball reply by turning Megan's own argument against her. They promise to pay her for her work in what could be considered a short amount of time on the geological scale - which could easily be many, many times longer than Megan's own lifespan. Megan, like all working people, wants to be paid in a timely manner for her work,[citation needed] and would be deeply dissatisfied to have her payment delayed for so long. Thus, Hairbun and Cueball's rebuttal proves a point: when other people require you be punctual, it's easy to dismiss them as just being impatient; when you're the one who needs other people to be punctual, it's not so easy to criticize yourself.

The comparison with a football field is a typical, but doubtful practice to explain people what the size of an area is (1257: Monster). Here it is used as an analogy with a one-dimensional timescale.

## #2188: E Scooters

August 12, 2019



Obviously battery technology and prices have driven a lot of the scooter explosion, but I feel like Dean Kamen must be at least a little grumpy about how much people laughed at the idea of the Segway.

## Explanation

At the time of publishing, motorized scooters or e-scooters were very popular, especially with the rise of ride-share companies such as Lime and Bird that use apps allowing users to rent the scooters by the minute. (Randall uses "e scooter" or "E Scooter" for the comic's title. But in the comic White Hat does say e-scooter, which is also the way the Wikipedia article on e-scooters mentions them.)

Cueball drives up to White Hat on his e-scooter. White Hat asks him for his thoughts on the scooter; he is interested as he has heard so much about them. However, instead of just waiting to hear Cueball's response, White Hat then goes on to list four opinions he has heard other people say about e-scooters:

When White Hat finally stops talking, Cueball tells him that he has given this a lot of thought and says he will give him his opinion on e-scooters. But instead of choosing an opinion from White Hat's list, or any logical opinion at all for that matter, Cueball starts making engine/vehicle sounds. This may indicate he doesn't care about any of White Hat's complicated opinions and is just excited about the fun of riding an e-scooter. In the last panel Cueball also makes "pew pew pew" sounds and other sounds from shooter-type video games, perhaps indicating that for him, riding a scooter is akin to the fun he gets from playing such video games.



Some people consider e-scooters as a "low-carbon car replacement", as they are better for the environment than polluting gas cars (while others consider the resources used in their creation and their disposal a bigger threat). Additionally, e-scooters have been touted as a form of "last-mile transit" - used to cover the "last mile" to your destination after taking other forms of public transportation. However, others consider e-scooters a public nuisance, as users often leave them on the sidewalk haphazardly; hence the question about them being clutter. The comment about them being specifically "Silicon Valley" clutter is due to the expense, the city-infrastructure needed, and the high-tech nature of these devices. Many of the e-scooter companies are also from the Silicon Valley area. Scooters have also been seen as dangerous ("unsafe toys"), as many users do not wear helmets when riding e-scooters (though Cueball is seen with a helmet in the comic, although not wearing it) or ride them at high speed on sidewalks with many pedestrians. Some cities have gone so far as to ban e-scooters from their communities.

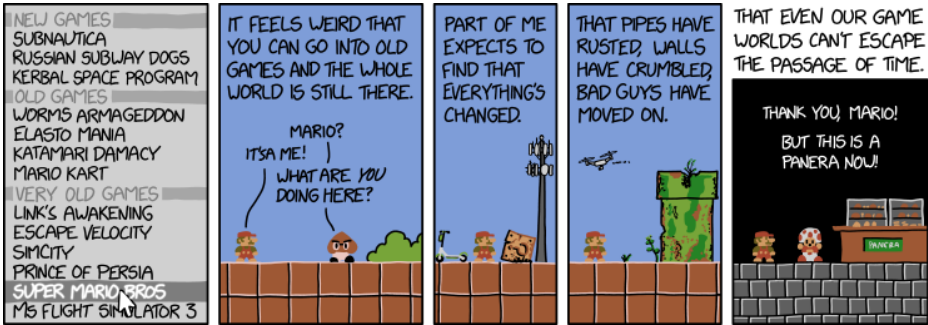
Cueball's response of making onomatopoeic sounds which mimic the e-scooter is humorous for two reasons. First, e-scooters are fun and may seem futuristic, like something from his childhood. This would bring out a youthful and childish joy children have when making engine noises when playing with toy cars. He is acting like a kid because riding a scooter makes him feel like one. The second reason this is funny is that the scooters, being battery-powered, are nearly silent. He is making the

sounds a traditional motorized scooter makes to fill in the audible gap. It is unclear why the scooter has lasers. Part of the joke is that there is no good or logical explanation for them. This forces the reader to come up with their own devious or honorable plan Cueball is executing. Not knowing why makes it more sinister and mysterious.

The title text refers to Dean Kamen, an American inventor best known for founding the Segway company. At the time of the invention of the Segway, it was billed as a revolution in personal transit, with articles (and Kamen himself) speculating that future cities might be entirely rebuilt around it and similar personal transporters. That buzz quickly died down, and Segways became the subject of a great deal of mockery. The text implies that Kamen might resent the fact that a similar vision has re-emerged and is once again being taken seriously, but without his invention. However, Segway actually manufactures scooters for e-scooter rental agency Lime.

## #2189: Old Game Worlds

August 14, 2019



Ok, how many coins for a cinnamon roll?

## Explanation

Randall sits at his computer looking at a menu of games which have been ordered into three sections, New, Old and Very old games (see List of games below). At the bottom of this list, 2nd to last, he chooses to click on Super Mario Bros. which then opens as shown in the next four panels.

This comic explores the difference between the real world, where artificial structures require constant upkeep and communities change with time, and the digital worlds of video games, where everything is static until the plot demands otherwise. Although online games do require server maintenance by the owners and sometimes receive major changes to their content, offline games are - and always have been - perpetual existences, unchanging so long as the data is intact. (This is later revisited in 2221: Emulation)

As the narration explores this incongruity, and theorizes about the idea of it not being so, the comic displays the alternative with the ubiquitous video game - Super Mario Bros. (1985) - as an example. Mario arrives in World 1-1 to find a Goomba expressing surprise that the plumber has deigned to return to the place where his first journey began. As he advances, he finds both signs of progress - a cellphone tower, an e-scooter, a drone - and signs of disrepair - damaged Warp Pipes, loose blocks. At World 1-4, he finds Toad; in the game, Toad would warn him that the Princess is being held in another castle, but now,

he's informing Mario that the castle has been remodeled into a Panera bakery.

This reflects common experiences of a person returning to a place they once knew well, but haven't seen in a long time. The atmosphere of the place may be changed by modern elements that hadn't existed before. Buildings and other infrastructure may have decayed or fallen into disrepair. And areas that have not been neglected will often be redeveloped, meaning that landmarks you remember may be repurposed or demolished to make room for something new. This tends to stir up feelings of nostalgia and loss in real life, when the settings of your memory no longer exist in the form that you remember.

The title-text abruptly switches to Mario's acceptance of the changes to World 1, and deciding to make the most of it by purchasing a cinnamon roll. "Coins" are the omnipresent currency of the Mushroom Kingdom and most other locations Mario visits in the Mario series, taking the form of large nondescript golden circles, usually with a rectangular indent in the middle.

The concept of an old, dilapidated version of the world of the original Super Mario Bros. was explored by Nintendo themselves in the Mushroomy Kingdom stage featured in multiple Super Smash Bros. games.

Playing old games is also the subject of 606: Cutting Edge.

**List of games[edit]**

The first panel shows a list of games in approximately reverse chronological order of their release:

The first game in the Mario Kart series was Super Mario Kart from 1992. As can be seen that Mario Kart game would be older than Link's Awakening. So it seems likely Randall was referring to Mario Kart 64 from 1997, the first in the series to begin with Mario Kart leaving out the Super. With this in mind all the games in the two bottom sections are older than all those in the previous section. But they are not listed chronologically within the three sections.

Russian Subway Dogs is the newest game from 2018 (and at the time of this comic's release in August 2019, is the only one of the 13 games mentioned in this comic that does not currently have a Wikipedia entry).

Super Mario Bros., the game most prominently featured in the comic, is the oldest of the 13. The first version of Microsoft Flight Simulator, MS flight simulator 1.0, was from 1982, but the list this comic specifies the third version, released in 1988.

Although the games in this comic appear to be grouped by date of their release, the time span covered by these groupings is not uniform. The first three games mentioned are from 2014-2018. The next four date from between 1997-2004, and the last six from between 1985-1996. With the earliest games grouped as 1985-1996, uniform grouping could split the later games between a group released in 1997-2008 and a group of games released in 2009 or later. If grouped by decades, 1985-1995 would potentially place the Escape Velocity game in the Old Games section instead of the Very Old Games section. Although some of these games

did have releases intended to run on a 'Personal Computer', the list in this comic seems to focus on games released for gaming consoles, with no mention of games released for first or second generation consoles which pre-dated the Nintendo Entertainment System (such as Pong published by Atari; Brain Wave, Haunted House, Interplanetary Voyage, & Wipeout for the Magnavox Odyssey; & Adventure for the Atari 2600).

## #2190: Serena Versus the Drones

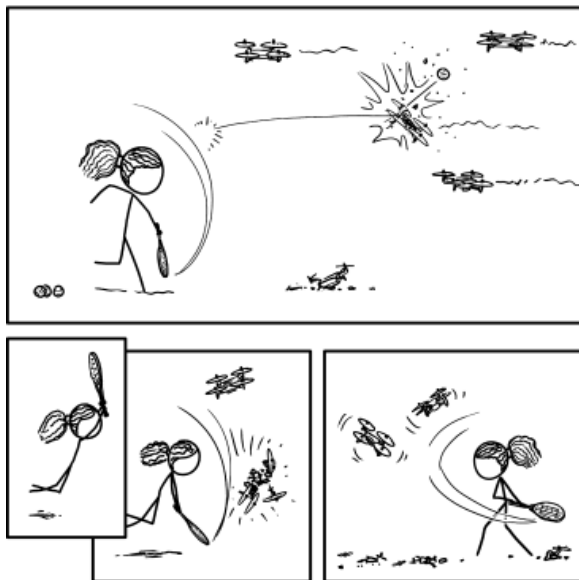
August 16, 2019

"IT'S A PRETTY BAD IDEA."

—SERENA WILLIAMS  
ON MY IDEA



WHICH TYPES OF SPORTS EQUIPMENT WOULD BE MOST EFFECTIVE AT BRINGING DOWN A ROGUE PHOTOGRAPHY DRONE? MY NEW BOOK FEATURES A REAL-WORLD TEST BY SERENA WILLIAMS.



TO READ AN EXCERPT ABOUT SERENA'S DRONE BATTLE, CLICK [HERE](#) OR GO TO [BLOG.XKCD.COM](#)

After the test, she said that if she had a choice, she wouldn't defend herself against drones using a tennis ball and racket, though she would absolutely pick them over other sports equipment. But, she added, "Drones don't



bother me."

## Explanation

Another comic which is a promotion of Randall's upcoming book *How To*, to be released less than 3 weeks after this comic's release, on September 3, 2019. And this time permanent - as opposed to *Disappearing Sunday Update* from about two weeks before. It stars Serena Williams, an American professional tennis player and former world No. 1.

Most book advertisements feature laudatory quotes from famous people or reviewers, but here, Serena Williams is quoted as saying "It's a pretty bad idea" about Randall's idea of her attacking drones as given by the title of the comic. That idea is one of the chapters in the book and Serena Williams actually agreed to go and shoot tennis balls after an old drone with a broken camera. This can be read in the *Blag* post that is linked at the bottom of the comic: *Serena Versus the Drones*. Unlike other books, "It's a pretty bad idea" is a pretty good quote for his "*How To*" book given that many of Randall's humorous explorations of scientific methods of doing usual and unusual things are pretty bad ideas.

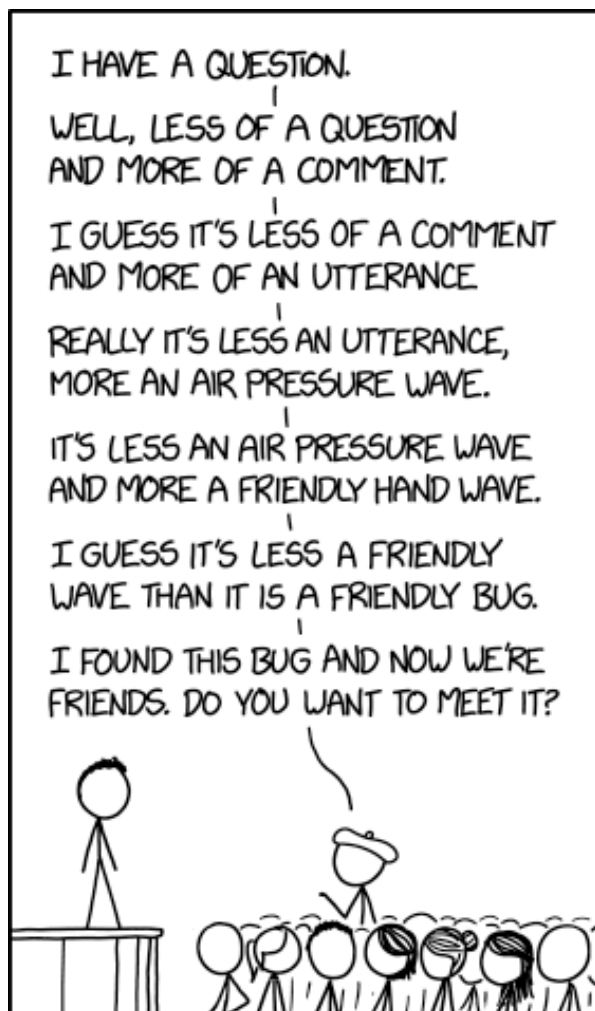
As usual with Randall there is no need to click on the link, as the entire image is a link to the blog post. This was mentioned in 1572: *xkcd Survey*, and even earlier in the banner for his book tour for the *What If?* book.

The title text says that Serena Williams said that if she wanted to defend herself against drones and if she had to

use sports equipment, she would use a tennis racket and ball. Notably, according to the Blag post, this would be ineffective compared to throwing.

## #2191: Conference Question

August 19, 2019



I also have an utterance. Less of an utterance and more of an incantation. Less of an incantation and more of a malediction. Less of a malediction and more of a Word of Power. Less of a Word of Power and more of an

Unforgivable Curse.

## Explanation

Usually, at a conference or other event involving a speaker addressing a crowd, members of the crowd are given the chance to ask questions. This is intended so that people can perhaps ask the speaker to elaborate on a point they've made, or to ask the speaker's opinion on a topic related to their talk.

Occasionally, people at such an event will use (or, rather, abuse) the opportunity to ask a question to instead provide their own (unsolicited) opinion or statement. Such statements are often preceded with something along the lines of "I have a question. Well, less of a question and more of a comment." This formulation in particular has attracted a lot of criticism for not adding anything to the discussion and for pulling focus away from the speaker.

In the comic, this idea is taken to an extreme, with Beret Guy not only transforming the opportunity to ask a question into an opportunity to make a statement through successive rephrasing, turning this into an opportunity to show off a bug he has found. This is accomplished by using a multitude of synonyms in a continuum of relatable word pairs, except near the last: "question" and "comment" are similar, as are "comment" and "utterance", but the extremes, the difference between the first and the last in the entire set (in this case "question" and "friendly bug") is profound. In a way, this segue is meant to be similar to how, in the lines of a color

spectrum, red fades into yellow: gradually, and with no abrupt transitions in color (YMMV: CGA versus 4K).

The title text takes the opposite route of Beret Guy, and each step instead refers to successively worse forms of magic spells that would, presumably, have a negative effect upon the listener. There is a certain xkcd character that is likely to do this. Starting from a mere utterance and then using Beret Guy's "it is less than" scheme, it progresses over worse and worse curses, ending with an unforgivable curse!

The title text can be interpreted as a reply by Hairy (the speaker) to Beret Guy, indicating his annoyance at the topic being derailed. It could also be representative of Randall's feelings towards those who abuse the opportunity to ask a question in order to make a statement. Randall has recently done some book tours and was at San Diego Comic-Con last month where he served on various panels, so he probably has had personal first-hand experience with these kinds of circuitous non-questions.

**#2192: Review**

*August 21, 2019*



GREAT GRAPHICS, HUGE WORLD

MY OVERALL REVIEW OF EARTH

Controls are a little hard to figure out.



## Explanation

This comic is a five star review of planet Earth, by Randall, depicted as Cueball in his profile picture. The review is written as a video game review, praising the size and aesthetics of the world. The comic's humor draws from the fact that gamers cannot use reviews to decide whether they want to "play" the Earth,[citation needed] and the fact that there's no place that the Earth can be reviewed (with the possible exception of Google, Yelp, or The Hitchhiker's Guide to the Galaxy). The "huge world" remark is a play on Open world games like The Witcher 3: Wild Hunt, which are praised when their size allows hundreds of hours of exploration; exploring Earth would allow more than a few hundred hours of novelties.

Earth (or humans and other life forms on Earth) has many problems at the moment, such as war, climate change, overpopulation, gun violence, sexual violence, censorship, poverty, and increasing depression, to name just a few. This comic serves as a reminder that, despite these issues, the world is a five-star world. It encourages us to look around: there's a lot of world to explore.

A game of fictional reviews of Earth can be found on the website [neal.fun](http://neal.fun) on Earth Reviews.

The title text states that the 'controls are hard to figure out', possibly alluding to the fact that it takes a lot of time to learn how to walk and talk, a rather basic thing in most video games, or to the fact that it is in general hard

to navigate around in one's life, as has been the subject of many comics.

While there aren't any games that can recreate the detail that reality has (Due to the computing power required to do such a thing would be on an intergalactic level to recreate Earth 1 to 1 in a simulation), there are some games that attempt to have a map that is similar in area or graphics that look as detailed as reality. However, there are many games that have successfully implemented difficult game-play/hard to learn controls.

Examples of games with large worlds: World of Warcraft, Fallout 3, the Red Dead series, The Elder Scrolls V: Skyrim, Minecraft, the Grand Theft Auto series, The Witcher 3: Wild Hunt, The Legend of Zelda: Breath of the Wild, Elden Ring.

Examples of games with difficult controls: the Souls series, Bloodborne, Stephen's Sausage Roll, Getting Over It with Bennett Foddy, Elden Ring.

## #2193: Well-Ordering Principle

August 23, 2019



We could organize a nationwide old-photo-album search, but the real Worst McFly is probably lost to time.

## Explanation

This is one of five other comics relating to genies:

- 152: Hamster Ball
- 879: Lamp
- 1391: Darkness
- 532: Piano
- 2741: Wish Interpretation

In the comic, Megan has found a genie lamp. A genie (or Jinn) in a lamp is a supernatural, immortal being from many fairy tales, the most well known that from Aladdin, who grants one or more wishes to the person who frees it, such as by polishing or opening the lamp. Instead of wishing for multiple wishes, flight, money, or other "traditional" wishes, Megan instead wishes to see the worst Marty McFly Halloween costume.

Marty McFly, played by actor Michael J. Fox, is a main character of the science fiction film about time travel *Back to the Future*, which was released, we are reminded, over thirty years ago, starting a series of sequels. The films are popular, so many people dress up as McFly or Doc Brown, the other main character, on Halloween, a holiday on October 31 when it is traditional in the USA to wear different costumes. McFly's outfit in the original film consists of little more than an orange vest, jean jacket, checkered shirt, jeans, and sneakers. It would seem difficult to get this wrong.

In the final panel, the genie questions why she would wish for something so mundane, when he has the power to grant wishes beyond her wildest dreams. Megan, being savvy of tropes, used in fiction since biblical times, points out that encounters with wish-granting entities often turn out to be traps. Genies in fiction will often interpret wishes in ways the wisher did not intend, and particularly mean-spirited ones will twist a mortal's desire into their own personal hell. Even when the wish-granting entity isn't malicious, they're often portrayed as carrying unintended consequences, such that extremely consequential wishes become extremely dangerous. So Megan tries to play it safe by wishing for something innocuous and with little room for harmful side-effects. Unfortunately, Megan appears to have forgotten the overarching trope: all wishes can be twisted against the wisher.

The genie may also be reluctant to fulfill the wish due to the insurmountable practical difficulties of fulfilling such subjective, ill-defined request. The well-ordering principle is a mathematical fact stating that every non-empty set of positive integers contains a least element; a generalization of this is the well-ordering theorem which is equivalent (given Zermelo–Fraenkel set theory) to the axiom of choice, the subject of 982: Set Theory. This principle would apply to Megan's request if there was guaranteed to be an absolute worst costume of Marty McFly. However, subjective preference, while reflexive and transitive, is not well-founded (or symmetric or necessarily antisymmetric or (semi-)connex

for that matter) and is therefore considered to be a preorder, also called a quasiorder. This means that the genie may not be able to fulfill Megan's wish if the selection is based on the preferences of any one person. For example, the genie may have no opinion on the quality of any McFly costume, or might judge them on criteria completely different from Megan's. Her own criteria might apply to some pairs of costumes but not others, leading to ambiguity as to which is the worst, and no way to say whether any of the candidate possibilities are as bad as the others.

While Megan isn't explicitly wishing for a common or widely-shared opinion, the title text contemplates organizing a "nationwide" search. People's preferences can be combined, such as with a mean opinion score which, while not strictly well-ordered, is usually able to identify a single worst costume, or at least a set of costumes tied for worst place according to aggregate subjective preferences. There are many other ways to combine preferences (e.g. voting) but none of them meet all of the criteria considered desirable, as demonstrated by Arrow's impossibility theorem. There is no way to exclude the possibility that even an omniscient and omnipotent genie might be technically unable to fulfill the wish, at least without, for example, changing one or more persons' preferences or modifying the space-time continuum to retroactively change the quality of some costumes of the past. The genie could fulfill the wish by showing Megan every McFly costume ever worn, which would necessarily show her the worst by any possible

definition, but could be the trap she was hoping to avoid because viewing all the "hundreds of thousands" would take an inordinately long time.

The title text may explain why Megan is interested in this wish: any means available to her would be restricted to a geographic area's (nationwide) photographs or drawings from memory. It is likely the worst costume was either never photographed, or isn't remembered accurately by those who saw it (it is "lost to time" -- which usually is just a figure of speech, but may actually be literally true in this case given the Back to the Future series' central theme of time travel). By asking the genie to show her, she might be able to see the truly worst costume without being restricted to only those for which evidence remains. Such a wish fulfillment might even require actual time travel to the time and location where the costume existed. The title text can also be interpreted as Randall's wish to know about the worst costume. So this is not Megan but Randall who has the wish to see this costume. The best we can do today is to look through all the available photos of McFly costumes. But even if one of those could be agreed upon to be the worst, there is no guarantee that there is not even worse versions that is not documented for posterity. In this interpretation, what Randall really would like is to use a dangerous genie wish to get around these difficulties.

An additional, subtle pun plays on the word "well". In European folklore, water wells are often associated with spirits which may grant wishes, similar to genies. Thus, Megan's explanation of why she made a simple request of

the genie is a statement of her "well-ordering principle"; her principle for ordering wishes from wells. (See also the Well series).



## #2194: How to Send a File

August 26, 2019



Note: *How To* will teach you lots of cool stuff about technology, data storage, butterfly migration, and more. Also you will never see your files again.

## Explanation

Similar to 2190: Serena Versus the Drones, this is another teaser ad for Randall's new (at the time the comic came out) book, How To, due to be released a week from this comic's release, on September 3, 2019. This also prompted a change to the header text. The comic shows an image from one of the chapters, and containing being a link to a larger piece of that chapter, or perhaps the entire chapter.

This comic discusses transferring files, previously discussed in 949: File Transfer and in the what if? article FedEx Bandwidth.. The snippet from his book that is shown in this comic shows scissors cutting off the (top) screen of a laptop, presumably as a way to give the "bottom" portion to someone for file transfer. While it is true most laptops house their hard drive in the bottom half of the machine, you would probably never need to prove it in a destructive manner. Tearing the screen off any given laptop is not a good idea.[citation needed]

It has not been unknown, in times past, for someone to take their 'computer' somewhere to be repaired and arrive with just the monitor (and perhaps the keyboard and mouse) unplugged from the 'box' (desktop or possibly under-desk tower case). This is because the owner has considered the latter to be little more than the 'disk drive' thing that reads the occasional floppy-disk, rather than being often the only absolutely necessary piece of equipment needed to be looked at – the

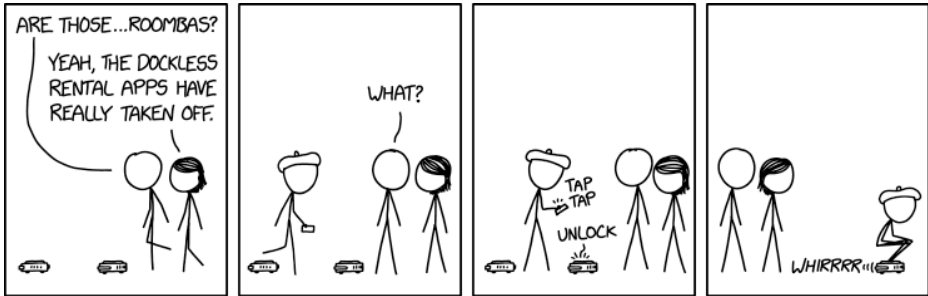
cumbersome CRT screen may well be far less necessary to take to a computer repairer, despite it being where "all my files" are commonly seen. The comic example may parody the above example with a more updated twist, but does also overlook that a number of slimline devices have touchscreen technology, and all the most important bits are included within the part with the screen, yet may also have a 'bottom half' keyboard that is optional and indeed removable (scissors not required!) while not actually including any of the relevant data.

The chapter linked to shows other methods of getting your files to another person and, in fact, explicitly states that breaking a computer to send files is not a good idea. The title text hints at other amazing content in the upcoming book, including discussion of butterfly migration (does it cause predictable tornadoes in Kansas? Can they carry coconuts to England?). It also threatens that using the book's idea for file transfer will make sure you will never see those files again, i.e. they will be lost for good if you try the book's method at home.

The chapter preview, that the comic links to, discusses using butterflies as a method of sending files from one person to another on the form of flash media attached to butterflies, or encoded in DNA, and goes pretty in depth into these particular methods of data transmission as opposed to the more traditional methods that are detailed in traditional computer science books.

## #2195: Dockless Roombas

August 28, 2019



The company started out exploiting a loophole in the law banning scooters. The city was mad at first, but then they noticed how much they were saving on street cleaning.

## Explanation

In this comic Cueball discovers two Roombas outside, and Megan explains that they are dockless Roombas for rent. Cueball is confused, but then Beret Guy walks in, activates one with an app on his smartphone, and rides away standing on it.

A Roomba is a small automated (robotic) vacuum cleaner designed to clean a room or other bounded area by repeatedly and automatically going over the floor, vacuuming, until it has made multiple passes, and either runs low on power or is turned off. The "intelligence" of various models can vary from relatively random operation with basic techniques to get around obstacles, to models that generate a general mental map of the area and contents and attempt to be deliberate in passing over all reachable areas. A Roomba generally includes a recharging "dock", which it can find and automatically connect with when it gets low on power, allowing it to recharge and perhaps automatically begin another round of cleaning. Roombas are a recurring theme on xkcd. In 1193: Externalities it was Ponytail that drove a Roomba. And in 1486: Vacuum Beret Guy flew on a regular vacuum cleaner.

A dockless scooter is a system of sharing personal scooters whereby they can be left anywhere for someone else to use, rather than returned to a particular home location. They are typically activated via a smartphone app. The term "dockless" in the name refers to the fact

they have no predefined home, or place to dock. Like a Roomba, they do need recharging, but no special station is needed for that -- anyone can pick them up and recharge them overnight from a standard power outlet, receiving a fee from the scooter company for this service. In the past several years they have become popular in many large cities around the world. Scooters have recently been featured in 2188: E Scooters.

The humor here is replacing the scooters with Roombas, which people would then ride. There are multiple problems with this idea:

- A Roomba is not powerful enough for someone to ride. At best, a small animal like a cat or squirrel might be able to ride atop one.
- A Roomba has small wheels and is designed for relatively flat and uniform surfaces. Even if a person could successfully ride on one, sidewalks have cracks and unevenness and bumps which would lead to a rough ride with lots of opportunities to get stuck. (But riding Roombas has come up on xkcd before, in the Externalities comic)
- A Roomba requires a way to recharge its batteries and, unladen, generally runs for an hour or so before it needs to be recharged. That is why it always comes with a dock. Dockless would imply it would not have a way to recharge. With a heavy load like a human, one would expect the run time to be drastically less.
- The cleaning capabilities of a Roomba require that it be

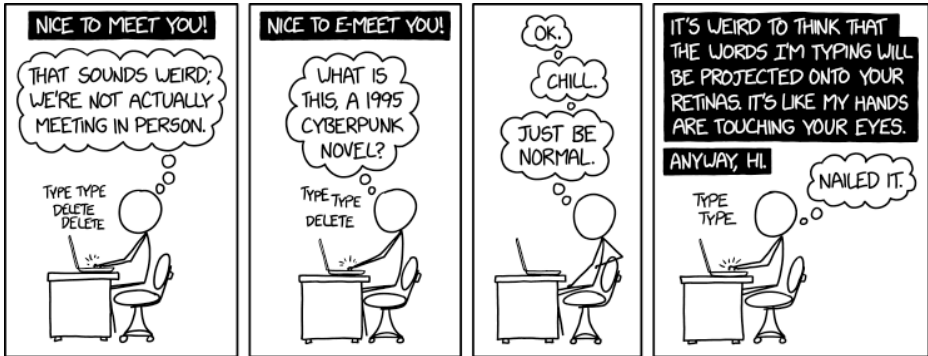
confined to a bounded area and that it go over the surfaces to be cleaned in multiple passes. A "free range" Roomba would not be very effective at cleaning.

- A Roomba's dirt canister is quite small and needs to be emptied when it fills up. This would happen quite quickly if it were operated on streets and sidewalks.

The title text refers to the controversy in many cities surrounding dockless scooters, which can be dangerous to pedestrians when in use and can block sidewalks and driveways when not. Dockless scooters were introduced in many cities before there were any regulations about scooter use, with some critics claiming scooters exploited loopholes in existing law and regulation, and leading some cities to pass legislation to specifically ban or curtail the use of dockless scooters. Here it is the Roombas that exploit loopholes in those scooter laws, which initially bothers city officials before they realize the positive benefit of the Roombas cleaning their streets as they are ridden.

## #2196: Nice To E-Meet You

August 30, 2019



I'm inside your head and I hate it. Please let me out.



## Explanation

In this comic, Cueball is considering how to greet someone online.

At first, Cueball considers simply saying "Nice to meet you!", a typical greeting used when meeting someone in person. However, he notes that since the introduction is taking place electronically, saying that he is actually "meeting" them is inaccurate; he duly discards the greeting.

Next he considers replacing the word "meet" with "e-meet." The use of "e-" as a prefix for anything related to electronics was a popular naming trend in the early 1990s, such as eWorld, eBay, and as a standardized shorthand for electronic mail. Earlier cyberpunk novels, such as 1984's *Neuromancer*, did not use the "e-" prefix, as they were written before that linguistic trend, while the prefix generally fell out of fashion by the 2000s. Cueball using the phrase "e-meet" thus sounds anachronistic to the 1990s, and he recognizes it, discarding his greeting again.

He then decides that he needs to throw off the shackles of normal conversation and simply "be normal." Being a geek, Cueball therefore writes up a long-winded exposition of how strange electronic communication actually is in terms of the photons being projected by the computer screen, comparing it to his hands touching the receiver's eyes, then concludes the greeting with a simple

"Anyway, hi." This might be off-putting to a friend that Cueball had just now met. This makes it funnier that Cueball believes he just "nailed" his greeting; he clearly has no idea what he is doing.

The title text continues the theme of "his hands touching the receiver's eyes"; Randall is talking about how as a construct that your mind makes, he is now "inside your head"-- and taking it that statement to its logical conclusion, he "wants to get out."

The comic discusses how adhering to conversational convention during social interactions can be quite difficult, especially with the advent of new technology. Social awkwardness is a recurring theme in xkcd.

Advice has been written regarding the topic of whether to use "Nice to (e-)meet you" and possible alternatives, e.g. by Forbes, Huffington Post and Grammarly. The consensus seems to be that "Nice to meet you" is fine, though a bit cliché.

## #2197: Game Show

September 02, 2019



THE GAME SHOW REALIZED THAT THEY  
SHOULD HAVE ADDED SOME RESTRICTIONS  
TO THEIR "TAKE ANY ITEM TO A DESERTED  
ISLAND" CHALLENGE, BUT IT WAS TOO LATE.

Eventually they agreed to "an auto-retracting dog leash with one end clipped to your house, so you can press the button on the handle and water-ski home."

## Explanation

Many shows have situations where the participants are asked hypothetical questions. A common hypothetical question asked to ascertain what someone considers most important to them is the one item they would take to a deserted island – to make the best of a boring situation.

Black Hat is on such a game show, and he does his best to undermine the intent of the question. Instead of answering with a favorite item – such as his favorite album or book – he goes on a WikiWalk through various things (see below), which he doesn't own and apparently expects the show's producers to provide him, starting with somewhat reasonable means of escape (e.g., a plane) to increasingly absurd items that appear to be chosen solely based on how difficult they would be to actually provide (e.g., the entire Atlantic Ocean). The items appear to follow Black Hat's stream of consciousness, starting with a boat, then a plane, then a distinctive lost plane, the bones of the pilot of that plane, the internal structure (similar to bones) of the famed landmark Statue of Liberty, etc.

The title text reveals that the game show has ultimately acquiesced to one of Black Hat's wishes in a way: the dog leash mentioned would allow him to water-ski home, though such a dog leash is implausible (for example, a dog leash from San Francisco to Hawaii would be over 2000 miles long).

## List of Black Hat's items[edit]

- A boat, so he could sail home.
- A plane, so he could fly home.
- Amelia Earhart's plane. Moving from reasonable methods of escape to more absurd items, Black Hat requests a plane that is currently lost and may never be discovered. Amelia Earhart was a female U.S. aviator who went missing in the Pacific Ocean in 1937 on an attempt to circumnavigate earth. The search for her crash site has gone on sporadically since she disappeared, and there's still keen interest in finding her -- and coming up with interesting new ideas to guess where she crashed. This answer is a funny continuation of Black Hat's 2nd answer, a plane. Black Hat doesn't just want any plane, he wants a plane that was famous for going down in a unknown spot in the ocean. If the producers of the show were to provide Black Hat with the plane they would have to first surmount an unsolved problem (i.e., where is Amelia Earhart's plane).
- Amelia Earhart's skeleton. Moving on from her plane, and being somewhat macabre in the process, Black Hat suggests Amelia Earhart's bones. Similar to her plane this would require the producers to find something that currently is not located. Also, given the biodegradability of bones there is perhaps a higher likelihood that the bones simply do not exist anymore, making the request potentially impossible.
- The internal structure of the Statue of Liberty was built by Gustave Eiffel, best known for his work on the Eiffel Tower. This is a continuation of the skeleton answer, as it is the internal support of the statue, similar to the function of human bones. It might also be a reference to the film Planet of the Apes, in which

the remnants of the Statue of Liberty serve as a famous piece of scenery. This does not require the search that Amelia Earhart's plane (or bones) would require, but might be equally difficult given the status of the statue as a national symbol and given that the statue is on an island in full view of many people who might object to interference. This is in addition to the logistical difficulties of transporting the internal structure of a large statue, and even extracting it whilst possibly not intending to disturb the now unsupported 'skin'.

- The Crown Jewels of the United Kingdom are a continuation of the theme of national symbols. The Crown Jewels are ceremonial objects owned by the kings and queens of the UK. The items are kept under heavy guard and are valued at about \$4 billion. Their acquisition would be nearly impossible[citation needed]; however, if they were acquired, it would result in an international hunt, which may help Black Hat escape the island.
- The entire television audience for the show, so it wouldn't be deserted anymore — and potentially to punish them for being entertained at the mean idea of having contestants be deserted on an island. If this is a popular channel/show, this could potentially be millions of people, all of whom have at least been exposed to the idea of making the most of a boring and potentially life-threatening situation. Then at least it would no longer be a deserted island, but of course it would be even more difficult to survive. This seems to follow from the previous point in that it is something that would trigger a massive search (in this case, due to not only a large group of people but a specific large group of people suddenly going missing).
- The Greenland ice sheet is the body of ice covering the island of Greenland. As the second largest ice sheet on Earth, it could

cause catastrophic environmental damage, ignoring the sheer magnitude of the task, which would be well beyond the capabilities of any television show[citation needed] and probably beyond the capabilities of an international effort. This one seems to follow from the previous point in that it is a massive undertaking to get the 'request' to Black Hat's island.

- Earth's north magnetic pole is the point on earth toward which all compasses point because of magnetohydrodynamic ('magic') forces in the earth's mantle. If all compasses were to suddenly point to his location, many scientists would investigate, they would converge on his deserted island, and Black Hat would be rescued. Moving the pole would be more difficult than moving the ice sheet, but it continues Black Hat's stream of consciousness in that it is a major geological feature of the planet.
- The Atlantic Ocean is another major geological feature. Moving it would be orders of magnitude more difficult than moving the Greenland ice sheet, and would cause abrupt and extreme changes to the planet's ecosystem.[citation needed] It is unclear how Black Hat would like the ocean delivered. If he wants it to remain an ocean separate from the Pacific, it would require a container of incredible size; if he simply wants the water, it would create a Sisyphean task unless the entire Atlantic Ocean was walled off from all other sources of water. Additionally, the Atlantic Ocean is far too salty to be drinkable, so it's not clear what use he could get out of it (and if he has — or requests — some kind of desalination equipment, it would work just as well on Pacific water). This continues Black Hat's stream of consciousness in that it is yet another major geological feature of the planet.

- A retractable leash (title text), to water-ski home. This would not work under normal circumstances, as the leash would have to be impossibly long.[citation needed]



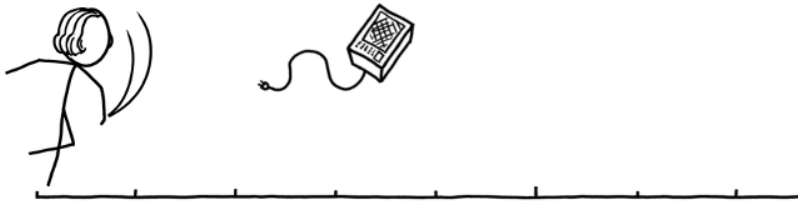
## #2198: Throw

September 03, 2019

### THROW CALCULATOR

THIS CALCULATOR IMPLEMENTS THE APPROXIMATE THROWING DISTANCE ESTIMATION MODEL FROM HOW TO CHAPTER 10: HOW TO THROW THINGS.

HOW FAR COULD GEORGE WASHINGTON THROW A MICROWAVE OVEN?



[CLICK TO VIEW INTERACTIVE COMIC]

this calculator implements the simple throwing distance estimation model from the how to throw things chapter of the book how to

## Explanation

This is an interactive comic made to celebrate the release of Randall's new book, *How To*. The comic is based on a chapter in the book.

As the comic celebrates the book, which was released on Tuesday, September 3rd, 2019, the comic was thus also released on a Tuesday to coincide with the release day, replacing that week's normal Wednesday release. This was the same timing used for another of Randall's book releases, when *1608: Hoverboard* came out on the Tuesday when *Thing Explainer* came out. Although the *Hoverboard* comic is much more complex than this one, they are both dynamic and interactive, and include animations. Also, the header text changed to promote the release creating a large combined promotion of the book during the three full days the comic was on the front page (see more [here](#)).

In this comic the viewer can select a thrower and an object to be thrown, see this [table](#), and get an animation of how the selected throw would work out, along with an estimated distance of the throw (both in the SI unit meter (m) and in other very arbitrary units; see this [table](#) below) if the throw was possible. Impossible throws include those where the thrower is not strong enough to throw the object, or when the thrower tries to throw themselves, which is possible as four "objects" are also listed as throwers, most prominently George Washington. As the picture above cannot show all the

possible selections in the two windows, pictures of all possible selections can be found [here](#)

The formula/guideline is apparently based on chapter 10 from the new How to book, see more under Formulas.

It seemed though, that there was a special case to the calculations with Thor's hammer (Mjolnir). Because this comic obviously refers to the Thor from the Marvel universe, played by another possible thrower, Chris Hemsworth in the Marvel Cinematic Universe, and his hammer, which is enchanted such that only those deemed "worthy" are able to lift it. As such, despite its mass in principle being liftable by many of the characters, only Thor, God of Thunder (who is canonically worthy), is able to throw it. Thor is also the only one who uses furlongs to measure his distances among the standard throwers. However, it is not a canonical part of this comic that only he can throw it, and its mass is not realistic, see more below.

Originally, when the comic was just released, there were only 7 throwers and 15 things to throw, giving a total of 105 different combinations; see the table below. But only Thor can throw all 15, with three of the objects (George Washington, Thor's hammer, and the car) unthrowable by any of the other throwers. The smaller critters can throw only a few things, so the total number of throws is much less than 105. Still, there is an animation for all 105 combinations, but with no throw distance for many of these.

But already on day one the comic was out, a new thrower was added with the standard name "You", and this person, Knit Cap, was also added to the objects that can be thrown increasing the number of throwers to 8 and objects to be thrown to 16. However, it would not be true to say that the number of options now would be  $8 \times 16 = 128$ , since the "You" can be customized when selecting it in the throwers menu (but not when selecting You in the object menu). When doing so a new window called Custom thrower will open up over the comic. The "You" option can then be customized by changing the name (from the default "You"), and defining the height (default 5.8 ft = 1.77 m) and weight (default 160 lb = 72.57 kg), where ft (feet) can be changed to m (meter) and lb (pound) can be changed to kg (kilograms). But when doing so the window will not correct the number from feet to meter etc. but stay the same.

Below the above options there is line with four persons above it, defining a scale of athleticism, the default second option being the drawing of "you" which represents Decent form (i.e. a normal person). The first on the scale is Black Hat, who thinks moving things is for suckers, thus representing minimal athleticism. "You" in second position is in decent shape and pretty good form, representing decent athleticism. George Washington in third position represents extremely high athleticism, and as he states he threw so well they made him President. Finally the fourth position, representing a champion athlete, shows a person with a helmet with chin strap and goggles who states that he trains 36 hours a day by using a

time machine. It is thus indicated that such athletes can only be so good by training more than is possible; for instance, if he travels 24 hours back every day, he could use 12 more of these to practice, making it 36 hours on that "normal day" and he would then still have 12 hours to eat and sleep/restitution before his next 36 hours training pass.

Changing away from the decent "You" to one of the other three characters on the athleticism scale does not, however, change the character used for the animation, which stays the same. But still this gives a very large number of different "yous" to both throw and be thrown.

A self-created character, unrealistically tall and heavy well over the human records for height (272 cm) and/or weight (635 kg), can actually be able to throw Thor's hammer (For instance 4m and 1000 kg, see more [here](#). So it is not because it is magically inclined to only be thrown by Thor, it is just that the weight is set to 2000 kg, and only Thor of the standard characters have the strength (1000 times normal human strength) to throw such a heavy object. But if the "You" is big enough, the athletic difference with Thor will be compensated by sheer weight and height. See this [table of data](#) from the comic for the above numbers.

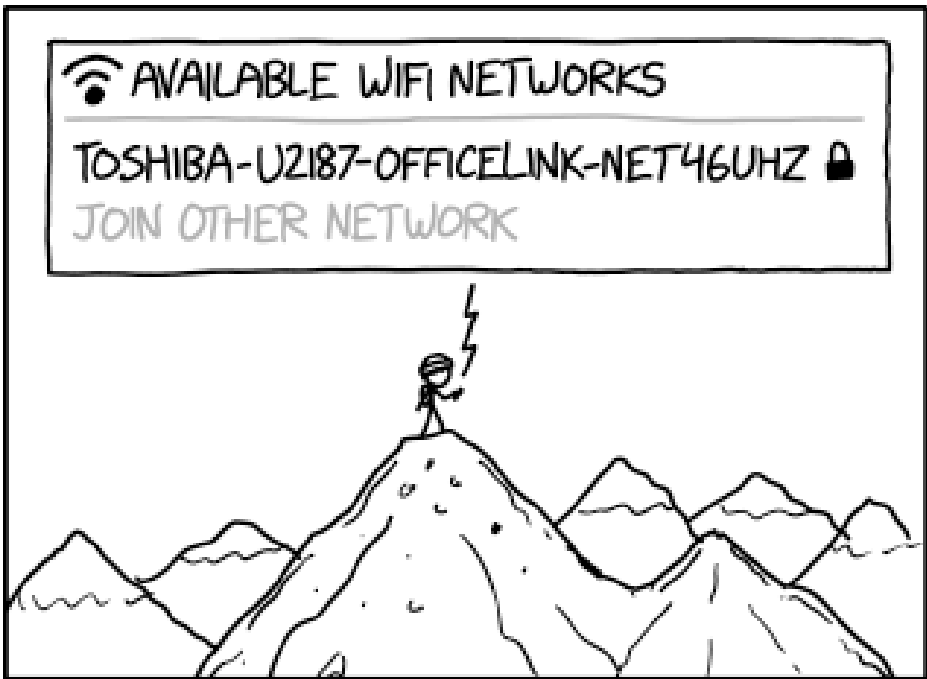
Interestingly, Thor can throw a squirrel 257 meters. If a Custom Thrower is created, and they are 200 meters tall and 150 KG, they can throw the squirrel 256 meters (1 meter less than Thor). Thor can throw an acorn 136

meters, and the Custom Thrower will throw it 133 meters. Now, Thor can throw Thor's Hammer 19 meters. The Custom Thrower can throw it 44 meters! Apparently there is more to the enchantment of Thor's Hammer than meets the eye, as it would have been expected that if Thor can throw a squirrel and an acorn farther than an extraordinary human, then certainly he could throw his own enchanted Hammer a longer distance. This is, of course, because the Custom Thrower now throws from much higher than Thor. As to why the height doesn't affect the acorn or squirrel throwing distance in the same way it does Thor's Hammer, we'll leave that to you, the reader.

The title text refers to throwing a party (a colloquial synonym of hosting a party) and first makes the assumption of actually giving hints for giving a party, and then switches to suggest a mechanism to literally throw a huge object, such as a house with a party going on inside. An aircraft steam catapult is a mechanism to launch aircraft from ships, typically used on aircraft carriers.

## #2199: Cryptic Wifi Networks

*September 06, 2019*



TECH TRIVIA: NO ONE ACTUALLY KNOWS WHAT DEVICES PRODUCE THOSE CRYPTIC WIFI NETWORKS. THEY JUST APPEAR AT RANDOM ACROSS THE EARTH'S SURFACE.

They actually showed up on the first scan by the first WiFi-capable device.

## Explanation

In the comic, Knit Cap is on top of a high mountain in a remote location (second comic in a row with knit cap). Mobile devices frequently launch a popup telling users to choose a network to connect to. Knit Cap sees a WiFi network name listed on a handheld device, perhaps a cell phone. The WiFi network seems to be a Business that uses Toshiba. This is something you would expect in a city, but certainly not on a mountain top, hence the joke, that what produced these WiFi networks are unknown, but seems to be distributed randomly over the face of the Earth, disregarding nearness to technology.

Cryptic Wi-Fi (or WiFi) network names, called Service Set Identifiers (SSIDs) are part of the joke about not knowing where the corresponding wireless router is located, suggesting they are unexplained phenomena instead of wireless radio devices. Some of the earliest WiFi devices like printers and internet routers advertised cryptic SSIDs, as do many of them today. Humorous SSID names are not uncommon.

The SSID displayed is Toshiba-U2187-OfficeLink-Net46UHZ which is 33 characters long, unfortunately one character more than allowed. Toshiba is a multinational electronics conglomerate manufacturing many products including untold multitudes of different kinds of printers over the years. Such devices often have embedded wireless access points including the manufacturer name in the SSID.



Many network names contain words like Net, Office or Link. The code might indicate a model U2187 device from Toshiba named (or having an interface program named) OfficeLink, which has a sub-model number or operates on a wireless network designated 46UHZ. That "Hz" is an abbreviation for Hertz suggests that designation may or may not have something to do with the frequency on which the transmitting device operates. U2187 could also be the Unicode character code for the Roman numeral 50,000 spelled "" or a serial number for a user or a utility pole. We don't know whether the SSID is connected to a network of more than one or is just one device. The padlock icon indicates that a password is required to communicate. The "join other network" option allows for manually typing SSIDs to attempt to connect with networks which are not configured to display their SSIDs.

While the most likely explanation in an office environment might be a printer plugged in somewhere nearby, other possibilities include a marsupial delivery drone, television, cryptocurrency mining rig, speaker, pacemaker, alarm system, offshore flying wind turbine, fashion accessory, autonomous antimissile defense system node, hobby project, surveillance device, balloon, distributed denial of service attack platform malware-infested coffee pot, satellite, vending machine, seawater dialysis station, telecommunication facility, solar-powered drone, distributed exoskeleton, visiting interstellar colony(?) ship, power-to-gas pipeline valve, ransomware worm nest, or anything else in the Wifi

Internet of Things. Sometimes, the ionosphere reflects radio waves, vastly increasing the distance that they can travel to and from remote locations, but this skywave propagation normally affects frequencies below 30 MHz, and never above 300 MHz, so they couldn't be the cause of receiving far away Wifi signals, which are 900 MHz and above.

The software which produces SSID listings is administered by network communities and depends on mesh configurations. (Please see also 1785: Wifi.) Alternatives include bluetooth mesh networks and other ad hoc networks to provide internet connectivity services.

The title text indicates that the first WiFi networking client interface displayed unexpected SSIDs. If true, this could potentially rule out all of the alternative explanations other than an alien visitation, a software bug, rogue industrial espionage, time travel, trans-multiverse or trans-dimensional communication, hardware misconfiguration, the simulation hypothesis, or the supernatural. (It is worth noting that cryptic-sounding WiFi networks generated by a time-traveling alien entity as a trap was used as a plot device in the 2013 Doctor Who episode "The Bells of Saint John". Doctor Who is a recurring theme on xkcd.)

## #2200: Unreachable State

*September 09, 2019*

### ! ERROR

IF YOU'RE SEEING THIS, THE CODE IS IN WHAT I THOUGHT WAS AN UNREACHABLE STATE.

I COULD GIVE YOU ADVICE FOR WHAT TO DO. BUT HONESTLY, WHY SHOULD YOU TRUST ME? I CLEARLY SCREWED THIS UP. I'M WRITING A MESSAGE THAT SHOULD NEVER APPEAR, YET I KNOW IT WILL PROBABLY APPEAR SOMEDAY.

ON A DEEP LEVEL, I KNOW I'M NOT UP TO THIS TASK. I'M SO SORRY.



NEVER WRITE ERROR MESSAGES TIRED.

**ERROR:** We've reached an unreachable state. Anything is possible. The limits were in our heads all along. Follow your dreams.

## Explanation

When writing a computer program, developers often need to make assumptions about what state the system could potentially be in at the time the program is executed. For example, a program designed to fetch data from a database requires that the database be accessible at the time it tries to fetch data; if it is not, then the program needs to know how to handle that state, or it might simply hang or crash the system. A good developer will have accounted for this possibility and may give the program a way to fail gracefully; often, this is done by outputting an error message to the user, to tell them what is wrong.

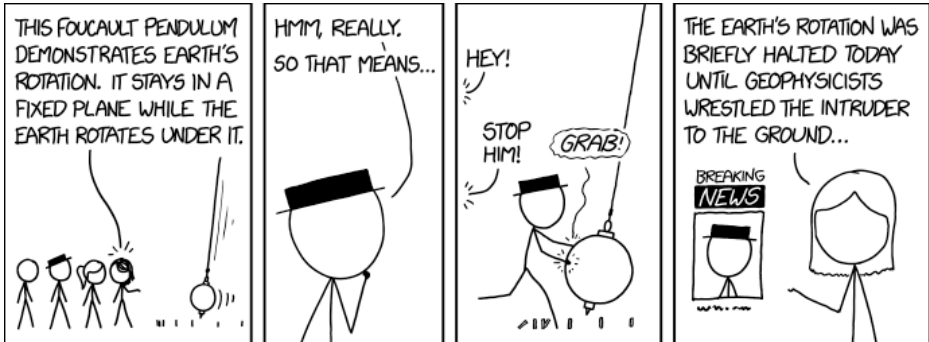
Sometimes, cautious developers will identify states that, in theory, should never be reachable at all - if they were, it would imply that something has gone fundamentally wrong. A paranoid developer might still decide to handle this case anyway, perhaps including a note that the situation should theoretically never happen, but they aren't confident enough to state with absolute certainty that it cannot.

This comic shows Cueball reading (or possibly writing) just such an error message from a program he is using. The developer has evidently written this text while tired (possibly from sleep deprivation), and did not trust themselves enough to be sure that the state is truly unreachable. The hopeless tone of the message supports this lack of confidence in their work.

The title text refers to the common trope of a character being given a "magic" item and winning something because of it, then being told that the item was not actually magic and that the magic was inside them all along. It is often used as a fable to tell people to follow their dreams. The title text puts the fable in a place where it doesn't belong, saying that finding the "unreachable state" that is the error code implies that the finder can do anything.

## #2201: Foucault Pendulum

*September 11, 2019*



Trust me, you don't want to get on the wrong side of the paramilitary enforcement arm of the International Earth Rotation and Reference Systems Service.

## Explanation

Black Hat is attending what appears to be a guided tour of a museum with a Foucault pendulum. Megan is explaining to him, Cueball and Ponytail about the device which demonstrates the rotation of the Earth.

Black Hat, being himself, immediately sees an opportunity to cause chaos and seizes it with both hands, quite literally — he grabs the pendulum, which causes the others to shout after him to stop. At first this would seemingly be for fear of ruining the delicate demonstration. However, in the final panel, the news anchor Blondie reveals to us that by arresting the motion of the pendulum, Black Hat has somehow stopped the rotation of the Earth. However, it was only briefly, since the local geophysicists managed to wrestle him down, and it must be assumed that they then quickly restarted the pendulum and thus the Earth's rotation.

This of course is blatantly impossible, since the Foucault pendulum's motion is tied to the Earth's rotation, not the other way around (at least in any significant way, see below). A Foucault pendulum is a regular pendulum that swings from a bearing that allows rotation in any direction, like your shoulder joint instead of your elbow, as a demonstration that the Earth is rotating beneath it. If the Earth were stationary, the pendulum's plane of oscillation would not change relative to its immediate surroundings, but the Earth is not stationary[citation needed], so the pendulum's plane of oscillation will

appear to rotate over the course of a day, although in reality it is the Earth that rotates. The low-friction bearing doesn't allow the rotation of the Earth to affect the motion of the pendulum, so it tends to stay aligned with its original inertial reference frame rather than with its surroundings, which rotate with the Earth. A Foucault pendulum located at one of the poles will take a full day to "move" one full round. At the equator there is no movement, and in between it will take longer than 24 hours (24 hours divided by the sine of the latitude).

The fact that the Earth's rotation does not influence the motion of the pendulum does NOT mean that other forces can't affect it - for example, someone running up and manually repositioning the pendulum. Of course, the apparent rotation of the pendulum's plane relative to the Earth is an effect of the planet's motion, rather than the cause of it. Thus, stopping a Foucault pendulum manually does not entail pausing the rotation of the Earth.[citation needed]

If it were somehow possible for a Foucault pendulum to control Earth's rotation (see above), Black Hat would probably not want to alter the momentum of the pendulum if he were not at one of the Earth's poles. That is assuming he was told that it was related to Earth's rotation and assuming that he would prefer to preserve his own life over creating chaos (unless he has some means to prevent his being slammed into a nearby wall at the speed of sound). This is because, if the rotation of the Earth were to be stopped for even very short amounts of time (a few seconds), it would cause everything on Earth



that wasn't bolted/fastened to the ground to move eastward compared to the now stationary ground. Objects near the Equator would suddenly be moving at a speed of 300-360 meters per second, likely causing the death of most lifeforms on Earth beneath a certain latitude almost instantaneously. Those close enough to the poles may survive, though. Also this will cause massive windstorms, tsunamis, volcanic and tectonic events on a scale not previously observed on Earth. This would likely cause a mass extinction event and wipe out most of humanity in the initial events (which would eventually lead to our total extinction). It is possible that Black Hat's grabbing the pendulum would cause a gradual slowing prior to stopping, minimizing the issue (though this doesn't seem to be the case), but the results would still be catastrophic, as the aforementioned events are still likely to occur (specifically the tsunamis and volcanic events). However, as mentioned above, if this pendulum were located at the South Pole, then Black Hat and other people around him would not be affected immediately, and he could both do it, survive and be stopped again. The question is whether there would be any more news stories to cover this, given what would happen to the rest of the world! If there was no one to readjust the pendulum's rotation, then certain events would happen after the initial damage (see this video ). Randall previously covered this scenario in detail in his What If? book, see XKCD's Creator Explains What Would Happen If Earth Stopped Spinning.

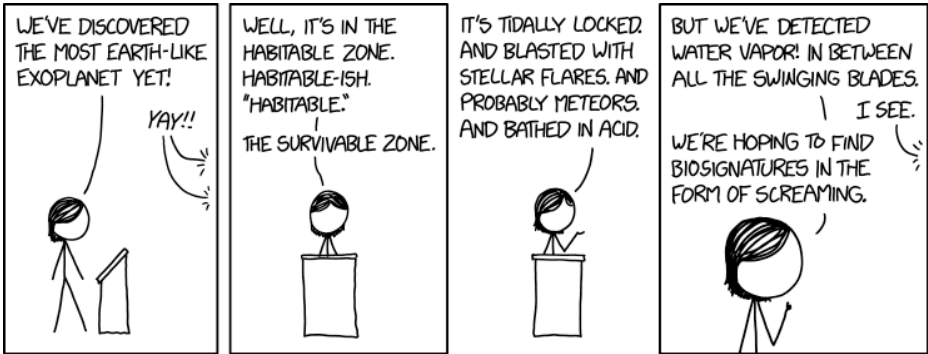
To be completely correct, the angular momentum of the

Earth+pendulum system is constant, so that when Black Hat "stops" the pendulum's rotation with respect to the Earth, he actually transfers to the pendulum some of Earth's angular momentum, thereby slightly slowing Earth's rotation. But the order of magnitude of that effect is (at most) in proportion to the pendulum-to-Earth mass ratio. Earth's mass being  $\sim 6 \times 10^{24}$ kg, the effect for any practical pendulum would be beyond the 20th decimal place and would therefore go totally unnoticed.

The title text mentions the International Earth Rotation and Reference Systems Service, an organization providing standards for global time and reference frames; this organization would have a very rough day after the fiasco with Black Hat. The title text refers to a (probably) fictional paramilitary enforcement arm of this organization and the foolishness of tangling with such a force. If Foucault pendulums were somehow able to influence the rotation of the Earth in any measurable way, the IERS enforcers would probably strictly control their installation and monitor their use (and misuse). Black Hat is likely in for a rough day as well. It seems likely that some on this team are geophysicists, since they were the ones who took Black Hat down.

## #2202: Earth-Like Exoplanet

September 13, 2019



Fire is actually a potential biosignature, since it means something is filling the atmosphere with an unstable gas like oxygen. If we find a planet covered in flames, it might be an indicator that it supports life. Or used to, anyway, before the fire.

## Explanation

This comic is a reference to the recent discovery of water vapor in the atmosphere of exoplanet K2-18b. The planet was discovered already in 2015 by the Kepler Space Observatory, orbiting the red dwarf star K2-18. Water on exoplanets is considered a biosignature, meaning it's an indicator that there could be life there. However, as Megan reveals the planet's other characteristics, it becomes clear that it is unlikely to actually support life, and in fact is actually a horrible hellscape. The question of habitability by higher forms of life is profoundly different from the way astrobiologists use the term for microbes. Even a "survivable zone" can't mitigate the description of just how inhospitable this new wet planet would be to life as we know it, save possibly for extremophile organisms. In the comic 1231: Habitable Zone, this zone was the subject.

The planet being tidally locked indicates that the same side would face the planet's star year-round, meaning half of the planet would be in constant day and the other half would be in constant night. It is believed that K2-18b is tidally locked. Based on our (admittedly limited) understanding of life, abiogenesis can only occur in environments with liquid water; however, the day hemisphere would likely be so hot that all water found there would be in a gaseous state, and all water found in the night hemisphere would likely be frozen due to the intense cold. If life were to be found on this exoplanet, it

would be in the twilight strip, a thin ring around the edge separating the two hemispheres where sunlight can reach but is refracted by the atmosphere. The environment in the twilight strip would thus experience something akin to an eternal sunset, and temperatures there would be moderate enough to allow life to come about.

Unfortunately, the other characteristics of the exoplanet severely undermine our chances of finding life even in its twilight strip, as there are many problems with the habitability of red dwarf systems.

- Stellar flares are ejections of radiation and plasma from a star, and a planet being blasted with these searing-hot flares probably wouldn't readily support life. These are common for red dwarfs, which can often be of the flare star type.
- Meteors are chunks of material that enter a planet's atmosphere, and if the planet is "blasted" by them it is likely that many of them are impacting the surface, thus becoming meteorites. As we know from the extinction of the dinosaurs, meteorites can have a sharply negative effect on a planet's habitability. There seems, however, to be no reason to believe this is a particular problem for this type of star system. This is where the comic starts to veer into absurdity.
- Strong acids are present in some planetary atmospheres, including sulfuric acid in Venus's, and their hypothetical presence in the exoplanet's atmosphere would make life there even less likely. While life that evolves in a highly acidic environment might be able to

withstand it, most life on Earth reacts poorly to strong acids. There is no reason to believe that the atmosphere of K2-18b is acidic. Apart from water the atmosphere mainly consists of hydrogen and helium. However, there is also reason to believe the planet has no solid surface.

Finally Megan describes the planet as being covered in "swinging blades." This could be a metaphorical allusion comparing the planet's dire straits to the Edgar Allan Poe poem "The Pit and the Pendulum," where the titular pendulum was a large blade swinging back and forth slowly. Due to the fame of Poe's work and the number of allusions made to it over the years, swinging blades have become a common feature in fictional deathtraps, and were used as an analogy to illustrate that the planet is chronically inhospitable to life. It could also be literal, a punchline to demonstrate the planet is so utterly inhospitable all life forms on the planet would have to squeeze between giant chopping razors.

"Biosignatures in the form of screaming" suggests that any life that had developed on the planet would be in continuous pain or fear due to their hazardous surroundings. In addition, this suggests that the screaming of these organisms would cause ripples in the atmosphere which we should be able to detect light-years away through the vacuum of space and that it would be more noticeable than other signs of life (such as the spectra from the ash produced by burning organic material.)

The title text mentions that fire could indicate the presence of life. This is because fire requires both fuel and oxygen (or some other similar, reactive gas). The occurrence of fire suggests that those things are both being continuously produced by some process. The most likely processes we know for producing oxygen are biological. The irony, of course, is that fire is also very dangerous, and almost universally lethal to organisms that are exposed to it for long enough. Munroe points out that oxygen reliably indicates that there was life, before the fire, with the implication that the fire may have killed everything.

## #2203: Prescience

*September 16, 2019*



I SAY THIS KIND OF THING EVERY SO OFTEN,  
BECAUSE I DON'T BELIEVE IT AFFECTS THE  
OUTCOME AND IT HAS A SLIM CHANCE OF  
LOOKING *INCREDIBLY* PRESCIENT.

Lots of people called their ships unsinkable before the Titanic. Voicing your hubris doesn't make failure more likely, just more memorable.



## Explanation

In this comic, Cueball states that it's been a long time since there's been a really big meteor impact. Due to the Gambler's Fallacy, this is taken to be Cueball implying that a big meteor impact is coming soon. The off-panel voice is annoyed about his statement, but whether from fear of it happening or because he does this all the time is unclear, see more below. The joke is that Cueball does this often, also with other types of major random events, just in case they do actually happen soon. For instance, if there does happen to be an impact soon after he made the statement, it makes him look incredibly prescient, whereas if there isn't one, no one really cares or remembers.

It is also unclear how big an impact he refers to. It has been 60 million years since the impact that killed the dinosaurs, but that if that is the type of event he refers to, then maybe no one will be there to remember what he said. So, it is likely much smaller impacts he is talking about. Prescience means to predict the future. It is clear from this comic that Randall makes fun of both of those that claim to have prescience and of those that have a superstition against talking about something happening that could cause it to happen. Although only one method is scientifically recognized, there are at least three possible sources of prescience recognized by people.

The first of the two main ways of predicting the future involves a mix of common sense and historical

knowledge. By understanding the past, the direction of the future can be guessed at with varying levels of accuracy. This type of prescience is also known sometimes as future modelling, statistical prediction, psychohistory, and even wisdom to name a few. The second way to predict the future is not scientifically recognized but remains popular in culture and fiction. It can involve magic, psychic power, higher powers (gods), and other such methods. Collectively, they are labelled supernatural; any method to predict the future using this class of method cannot be easily measured by science.

Although not technically a way to predict the future, the third way to predict the future is through superstition. The method involved in this comic effectively boils down to "speak the name of evil, and you will summon it." This superstition can have surprising power in people's lives, however. A woman planning her outdoor wedding may feel the urge to hit her friend if they say "Gosh, I hope it doesn't rain on that day." A doctor working in the Emergency Room may feel the need to kick anyone who says "Wow, it's really quiet around here." Such thoughts spoken aloud do not have the power to control the weather or cause people to seriously injure themselves. Yet people often react emotionally as if not speaking the name of 'evil' will keep it away.

This comic may reflect that emotional reaction when the off-screen character yells at Cueball: "Will you stop that?!". Alternatively, it is one, like Megan, who knows Cueball well enough to know that which is stated in the caption, that he only does this to look good if said thing

happens. And the person is so tired of it! Maybe Cueball does it at least once a week, and obviously from the caption, it is not only about meteor impact, but any major random event, that he could then be remembered as having predicted. The title has a double meaning. The first meaning is about the prescience that would appear if one actually predicts a natural disaster this way. The second meaning involves the fact that it is spelled pre-science - since there are many more scientific ways to predict meteor impacts, even though they aren't entirely accurate. This comic has a clear resemblance to the My Hobby series. This would also make it clear the Cueball in this comic is actually Randall. The entire setup and punch line of this comic is very similar to this old comic: 525: I Know You're Listening, and 628: Psychic and 858: Milk also use the idea of guessing something that will make you look special.

The title text refers to the RMS Titanic, a ship which was claimed to be unsinkable by those promoting its maiden voyage. The use of multiple water-tight compartments allowed the ship to suffer a moderate amount of damage without sinking. Unfortunately, there existed a way for the ship to suffer damage in a way which caused more compartments to be filled with water than it could survive; and, therefore, it could — and eventually did — sink. But with all the news stories that had just been published hailing this unsinkable ship as a modern wonder of the world, this shipwreck was particularly ironic. The story of the sinking of the Titanic has been memorialized in popular culture, most memorably in the

1997 film *Titanic*.

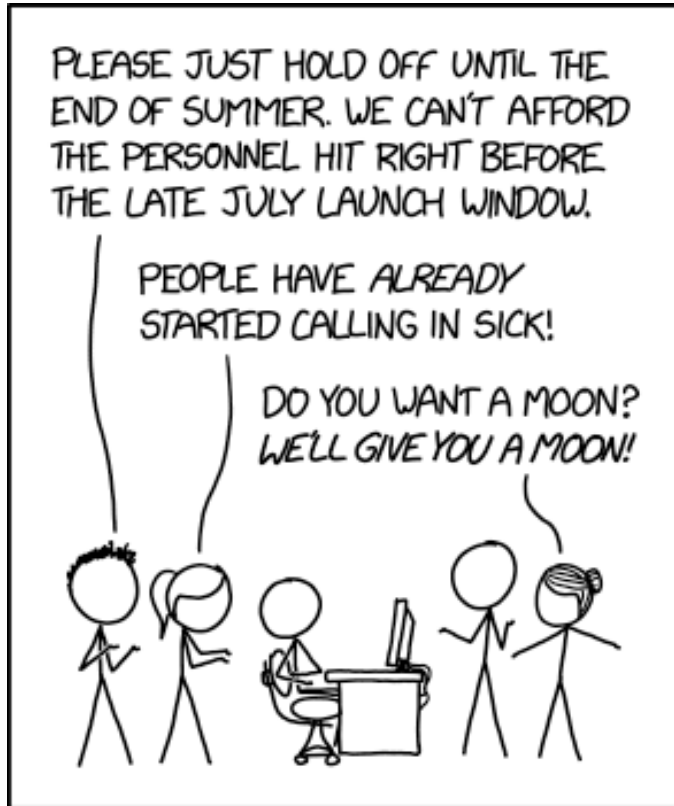
In the title text, Randall thus suggests that lots of ships had been called unsinkable before *Titanic*. But saying such hubris aloud doesn't make any ship more likely to sink. But when such a ship, like *Titanic*, then sinks it does, however, increase the value of the story ensuring it will be remembered. It should be noted that few among the ship's builders or crew boasted the *Titanic* to be unsinkable. Most of the boasting came from the owners that used the news media of the day to create hype and promote their ship, just when the ship was finished and dedicated (the ship's builders did, however, boast that the ship exceeded all safety standards of the time). In addition, the hubris was only one small part of the fame of the sinking of the *Titanic*; the *Titanic*'s status as a world record setter for most massive ship ever built, the incredible wealth of most of its passengers, and the fact it sank on its maiden voyage all contributed to the fame and hype behind the great maritime tragedy.

Ironically, part of what caused this disaster was hubris, since those that were interested in promoting the ship also wished it to make a speed record, by reaching New York a day before expected. Thus, the captain, even though he would have realised that the ship could sink, took the fateful decisions of running at full speed through waters known to contain icebergs during a still night with very calm waters. Spotting icebergs in such conditions is known to be difficult, especially as there will be no notably foaming waves around the icebergs' bases and patchy mists will inconveniently diffuse the

horizons and any useful starlight.

## #2204: Ksp 2

September 18, 2019



NASA TRIES DESPERATELY TO GET  
THE KERBAL SPACE PROGRAM TEAM  
TO DELAY *KSP 2* UNTIL AFTER THE  
*MARS 2020* MISSION LAUNCHES.

"The committee appreciates that your 2020 launch is on track, but the 'human capital/personnel retention' budget includes a lot more unmarked cash payments than usual. What are th--" "Public outreach."

## Explanation

Cueball, a programmer, is sitting at his computer while four other persons from NASA, Hairy, Ponytail, Hairbun and another Cueball-like person try to convince him to delay the release of a sequel to Kerbal Space Program (KSP 2).

Kerbal Space Program (KSP for short) is a space flight simulation video game with a Keplerian orbital physics engine, allowing for semi-realistic orbital maneuvers. KSP is a recurring theme in xkcd. A sequel, abbreviated here as KSP 2, was planned at the time of the comic's publication to be released in 2020, although it was delayed and released in February 2023.

Also planned for 2020 is the Perseverance mission, a Mars rover originally named Mars 2020, which successfully landed. The joke in the comic comes as engineers are likely to want to extensively play with KSP 2 to the exclusion of other things, and NASA is worried about the Mars 2020 mission being delayed or failing because the engineers are too focused on playing KSP 2, including taking an extended vacation and "sick" days off.

Cueball, sitting at a desk in front of a computer, is represented here as being in charge of KSP 2, and the other characters standing around him are pleading with him to delay the release of KSP 2 until the Mars rover program is complete, even being willing to "give [him] a

moon". (In 2655: Asking Scientists Questions, Hairbun again promises an oversized (for its task) reward, the task being filling out grant applications, the reward being coauthor credit, powerful magnets, or plutonium.)

Offering to give somebody the moon occurs occasionally in songs and poetry, as an idiom meaning desire to offer something of great value, or expressing great desire to please. Literally giving a moon to Cueball is impossible,[citation needed] but it is possible to name a moon after Cueball, so that may be what is implied instead.

The title text is a sentence said by someone from a committee in NASA that oversees the progress and budget of the Mars 2020 mission. They are satisfied that the launch in 2020 is still on track, but has a question regarding the 'human capital/personnel retention' budget, which has several unmarked cash payments, more than they would expect. As they begin to ask what they are, someone from the Mars 2020 project interrupts, having probably foreseen this question, stating that it is Public outreach.

In the original Kerbal Space Program, playing in career mode, the player can select various "strategies" at the administration building to exchange or boost various assets. "Public Outreach" appears similar to the "Public Relations" strategy "Appreciation Campaign", which exchanges a portion of in-game money earned completing mission contracts for prestige, which has an effect on mission contracts the game makes available.



The title text suggests NASA could be paying Private Division, the developers of Kerbal Space Program, money to delay their release until after the Mars mission.

NASA has dabbled in game physics engines for "public outreach," with the same mixed record of success as any promising R&D endeavor. Pertinent projects included a series of collaboration laboratories on various forms of social media including Second Life which hosted a "NASA CoLab" region active from 2007 to around 2013. While the unrealistic constraints imposed by real-time physics engine simulation prevented much actual engineering, such shared 3D computer aided design (CAD) systems provide a measure of drafting training in a play sandbox system outside of a formal work environment. NASA frequently holds design competitions, including some in which winning participants have spoken highly of KSP, and some of which are used for developments in medical informatics, for example, outside the field of aerospace engineering and space colonization simulation. The use of game development competitions to assist scientific progress is also used in the Fold.it competitive protein folding game, where the winners build antibodies to save the lives of those who have health care. Such efforts have often been supported by SBIR-sized government agency grants from several countries, along with other individuals (i.e., customer) support and help from organizations to build software improving competitive score achievement. NASA has also been involved in asking software publishers to remove, withdraw, or restrict their releases,

such as the COMSOL plasma physics engine library, rumored to be useful for the design of nuclear weapons. But whether any government agency has ever paid for the delay of a computer simulation game in order to increase their productivity is an open question.

An alternative suggestion of the title text is that NASA gave cash to employees, their families, friends, associates, and foreign spy followers to purchase additional copies of KSP 2 to encourage development innovations, international collaboration, as a "force multiplier" for personnel retention, and as bonus incentive awards for engineers who are ahead of schedule for their part of the Mars 2020 launch.

## #2205: Types of Approximation

September 20, 2019

### PHYSICIST APPROXIMATIONS

WE'LL ASSUME THE  
CURVE OF THIS RAIL  
IS A CIRCULAR ARC  
WITH RADIUS  $R$ .



### ENGINEER APPROXIMATIONS

LET'S ASSUME THIS  
CURVE DEVIATES FROM  
A CIRCLE BY NO MORE  
THAN 1 PART IN 1,000.



### COSMOLOGIST APPROXIMATIONS

ASSUME PI IS ONE.  
PRETTY SURE IT'S  
BIGGER THAN THAT.  
OK, WE CAN MAKE  
IT TEN. WHATEVER.



It's not my fault I haven't had a chance to measure the curvature of this particular universe.

## Explanation

In physics and engineering, problem solving typically requires approximations, as physical properties of the universe can be difficult to model. For example, in introductory physics classes, theories are introduced in frictionless environments. The level of precision required in a calculation or approximation varies depending on the context.

In the comic, Cueball, the physicist, generally dealing with theoretical constructs that can use relatively simple math, is introducing a problem with the assumption that the particular curve is a (perfectly) circular arc with a radius represented by  $R$ . Engineers have to deal with real things, which deviate from ideal shapes. Dimensions may be known to a certain tolerance. Megan, the engineer, also assumes that the curve is similar to a circle, with a deviation factor of  $1/1000$  or less.

The joke arises when Ponytail, the cosmologist, uses the much less precise[citation needed] approximation of  $\pi$  ( $\pi$ ) equal to 1.

Ponytail offering to use 10 instead of 1 alludes to Fermi approximations, as shown in Paint the Earth. Numbers are rounded to the nearest order of magnitude (1, 10, 100, etc.) using a base 10 logarithmic scale. On this scale, "halfway" between 1 and 10 would be  $\sqrt{10} \approx 3.16$ . Thus, numbers between about 0.316 and 3.16 are rounded to 1, between 3.16 and 31.6 are rounded to 10, and so on.  $\pi$

is an irrational number that can be approximated by 3.14, so it is very close to the 3.16 cutoff point. The closest order of magnitude to  $\pi$  is 100, or 1. Furthering the joke, Ponytail's calculations are so "coarse" she doesn't even particularly mind whether  $\pi$  is approximated to 1 or the other reasonable Fermi approximation, 101, or 10.

$\pi$  is defined as the ratio of the circumference of a circle divided by its diameter. This number is an irrational starting with 3.1415926535897932384626, the value for this ratio in a flat geometry. But in a curved space, the ratio might be different. The title text makes use of the fact that almost every number can be this ratio depending on the curvature of the space the circle is in. The cosmologist doesn't know the curvature of "this particular universe" (a funny way to state the universe the cosmologist lives in, which is not perfectly flat), and so  $\pi$  may not be the best value to use for the ratio between a circle's circumference and diameter.

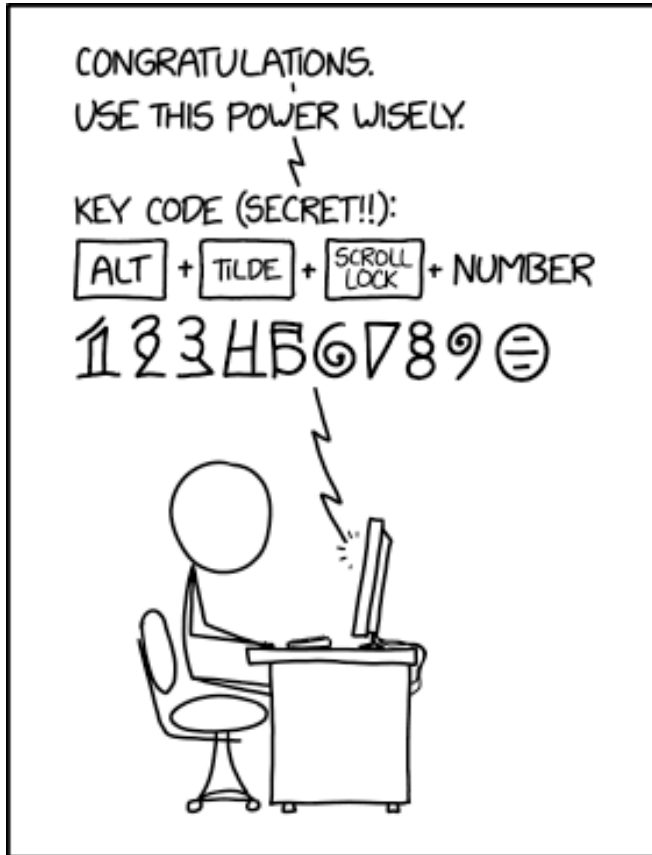
This comic is a parody of the tendency of cosmology to use much rougher approximations in their work that would horrify engineers, other physicists, mathematicians, etc. In general, cosmologists deal with distances, time spans, masses, etc. that are so vast, with such large estimated errors, that approximations that would be ridiculous elsewhere still yield useful answers in cosmology. When dealing with the large numbers in cosmology, small multiplicative factors like 3 vanish into the rounding error: there probably isn't a useful difference between 10100 and 10100.497, even though

these numbers differ by a factor very close to  $\pi$  -- an error that would greatly disturb most physicists and engineers.

Approximating  $\pi$  as 1 may also refer to the habit astronomers have of changing the units of measure such that important constants of the universe (such as the speed of light or the gravitational constant) are equal to 1, which highly simplifies the formulas without compromising the math. The number  $\pi$ , however, is a dimensionless ratio, which doesn't depend on the unit of measure.

## #2206: Mavis Beacon

*September 23, 2019*



AFTER 30 YEARS, I FINALLY BEAT THE END BOSS OF MAVIS BEACON AND UNLOCKED THE ABILITY TO TYPE CAPITAL NUMBERS.

There are actually lowercase-like 'oldstyle' forms of normal numbers with more pronounced ascenders and descenders, which is why some numbers like '5' in books sometimes dangle below the line. But the true capital

numbers remain the domain of number maven Mavis  
Beacon.



## Explanation

Cueball is being congratulated by the game he plays, Mavis Beacon, on his computer, because he has beaten the end boss and unlocked a new ability - the ability to type capital numbers...

Mavis Beacon Teaches Typing is a computer game first released in 1987, with the goal of teaching touch-typing and improving typing speed on a computer keyboard. Unlike many video games, Mavis Beacon contains no combat and therefore does not feature any "end boss" (a very powerful enemy encountered as the final challenge of the game). In many video games, defeating major opponents "unlocks" special features, such as improved weapons. Also, playing Mavis Beacon, although it may improve typing skill, has no effect on how typing works on one's computer.

In the caption, however, Randall asserts that after 30 years of playing Mavis Beacon, he encountered and defeated such a boss. Playing the same game for 30 years is rare.[citation needed] Regardless, Randall claims that defeating this "end boss" unlocked an ability to type esoteric "capital numbers," which Randall depicts as more extravagant versions of the familiar numerals. Although modern Latin letters have different letter case (i.e. capital or upper case and small or lower-case), Arabic numerals - the conventional numerals 0-9 used in the Western world - do not.

Stating that the game is old enough that it could have been played for 30 years, could be another attempt at making people, who actually did play the game in the early days, feel old (or an appeal to nostalgia). But this doesn't seem to be the main point of the comic.

Typing such numerals is said to require pressing the Alt, tilde (~), Scroll Lock, and numeral keys at the same time. Some keyboard layouts do not have a scroll lock key or a separate tilde key (such that pressing ~ actually requires pressing a shift/modifier key along with the ~ key), and in any event pressing four or five keys at once would be quite difficult. Needless to say, pressing all those keys simultaneously does not, in fact, do anything like what the comics describes in any known computer system, though some smaller subset of those keys together (i.e. "Alt ~" or "Alt numeral-key") might activate other operating system or user-defined shortcuts.

Keyboards vary in how many simultaneous key presses they can process (rollover). Computer keyboards for English may be limited to as few as 3 simultaneous keys, whereas other languages or higher quality keyboards may be able to handle an unlimited number of keys at once. (A musical keyboard might need to handle 10 or more simultaneous keys, likewise gaming or braille keyboards may need to handle many simultaneous keys.)

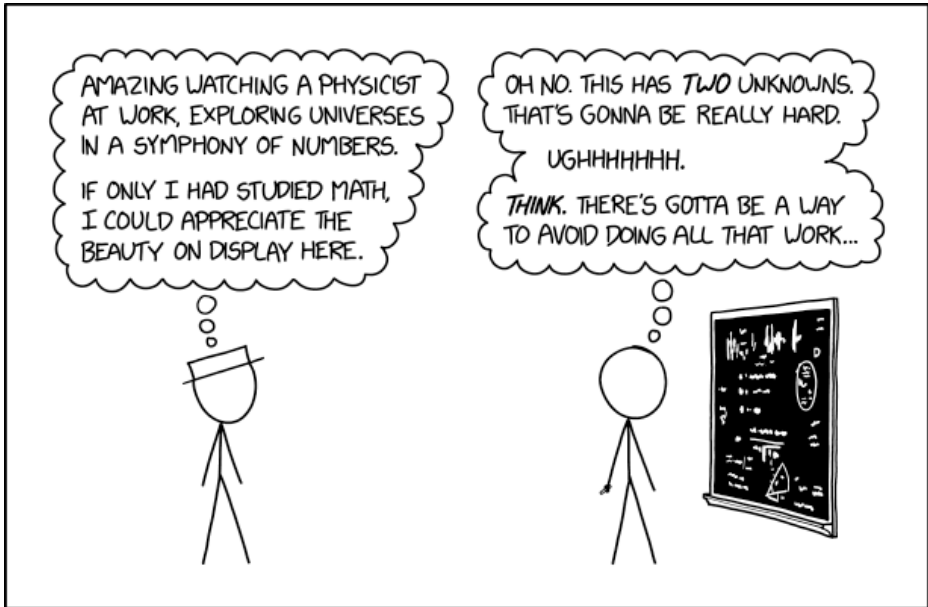
In the title text, Randall notes that certain typefaces feature text figures, numerals that have ascenders and descenders, much as lower-case letters do, rather than all standing at the full X-height like capital letters. He then

goes on to joke that, conversely, there are true "capital numerals," but they are a guarded secret of Mavis Beacon. Mavis Beacon was the character created as the typing instructor for the Mavis Beacon game, and is fictional, not a real person. Additionally, as a typing instructor, this person (even if she actually existed) would not be able to change typographical standards. Randall's description of Mavis Beacon as a "number maven" (that is, expert or connoisseur) contrasts with her supposed field of expertise in typing, which involves letters and punctuation more than numbers.

The comic itself hotlinks to this article: [Oldstyle Figures](#). It is about typographic oldstyle digits. The article asserts that oldstyle digits are also called "lowercase" digits.

## #2207: Math Work

September 25, 2019



I could type this into a solver, which **MIGHT** help, but would also mean I have to get a lot of parentheses right...

## Explanation

White Hat is observing a physicist, Cueball, who is staring at some (in the comic unreadable; see high resolution version) equations and diagrams on a chalkboard. White Hat is neither a physicist nor a mathematician, and seems to glorify those professions. He wishes he understood Cueball's work and "the beauty on display here." People who profess a love for mathematics often cite the beauty they see in pure math, how things work out so perfectly, as the reason they love math.

The joke is that Cueball as a physicist is doing something instead quite simple and relatable: Avoiding hard work. Solving many kinds of constraints for two unknowns isn't necessarily difficult, but can be depending on the details. Cueball clearly thinks a solution is possible but would rather find an easier route. The same could be said about the field of mathematics in general: A proof is beautiful to a mathematician when it provides aesthetic pleasure, usually associated with being easy to understand. A proof is elegant when it is both easy to understand and correct, and mathematical solutions are profound when useful. Record numbers of mathematics interest groups and their forums in which such work is done exist today, from academic journals predating the use of electricity to a plethora of internet math and science fora such as Wikipedia Reference Desks and Reddit's /r/theydidthemath forum, which fueled a resurgence of the phrase "they did the math" as a search

term in 2014, because it was included in the sidebar of the /r/xkcd subreddit, where it remains five years hence, between "Linguistics" and "Ask Historians," suggesting that the term was popularized by Xkcd fans after its initial appearance c. 1988. The proliferation of mathematics fora is certainly also due to the quickly increasing overall level of education and rapidly growing numbers of internet users.

The title text continues Cueball's thought process, with the possibility of using an automatic equation solver to find the unknowns. Equation solvers are not often considered beautiful ways to address purely mathematical problems, even if they are often the most efficient and in that sense elegant solutions to applied problems in engineering. Using a formal solver with symbolic, numeric, or both methods requires making sure that the constraints (e.g. equations) are entered correctly, with parentheses balanced in their correct locations for the solution to succeed. This might be a further joke about Cueball's laziness, suggesting that he doesn't even have the energy to check whether his parentheses are placed correctly. At the same time it might show how far away he is from finding the real solution: Any missing, misplaced or spurious parenthesis will most likely immediately invalidate the whole equation system. While the beauty of mathematics and pure physics may not be associated with automatic solvers in spreadsheets, general optimization methods are considered elegant in applied physics and engineering, with Jaynes (1957) cited more than 12,000 times on

Google Scholar, including by a paper cited by the first black hole image astronomers for example.

### **Examples of bivariate optimization[edit]**

A mathematical problem involving two unknowns could be a system of linear equations which can often be solved on paper, a blackboard, in a spreadsheet with solver functions, or by a computer algebra system such as WolframAlpha.com. Linear equations are a typical kind of more general constraint satisfaction problems, which in turn are mathematical optimization problems, where the minimization of a difference from a goal state (such as that all of the constraining equations are true, for example) indicates the extent to which constraints are met. Sometimes such problem solving activity arises naturally from economic transactions according to, for example, the laws of supply and demand, arising in the general context of civilization and ecology (both of which have properties associated with beauty and mathematical elegance.) Problems solved by economics are examples of distributed constraint optimization processes. When economic laws are not sufficiently satisfying constraints, that is a market failure, which indicates that more artificial and manual mathematical work is required, instead of the naturally arising or otherwise automatic methods contemplated by Cueball. Other distributed constraint optimization systems can be crowdsourcing games, such as FoldIt and Galaxy Zoo.

Of the graphic elements on the blackboard, the most distinctive appears to be a pair of wedges from a pie chart, where the radius of the slices is being used to represent another variable than the angles which all pie charts use to represent a primary variable. Since the cartoon is in black and white, the use of color to

represent category labels or more variables may be ruled out. Such black-and-white wedges represent two variables, the meaning of which may be unknown to us, let alone their values. The only distributed constraint optimization game which uses such wedges may be the climate stabilization wedge game from Princeton University. In that wedge game, angles represent a potential number of gigatons of atmospheric carbon mitigation (out of about 38 for the circle) and radius indicates uptake, or the extent to which the mitigation solution is effective.

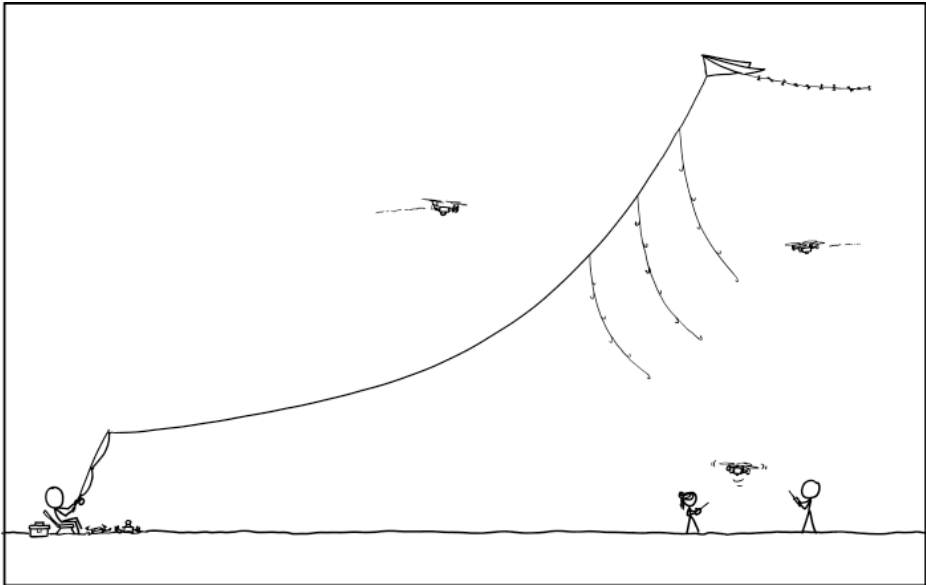
That game is an example of a bivariate optimization problem which might not have to be manually solved by anyone, for example under specific assumptions about the market in Project Foghorn plants and power-to-gas upgrades for natural gas power plants. If such market-based approaches to distributed constraint satisfaction are successful, then the work in finding the solution would be performed not entirely by physicists, chemical engineers, mathematicians, or intentional crowdworkers playing a game to achieve the optimal solution(s), but instead in even larger part by far more widely distributed crowdworkers who are simply making their own, ideally self-interested choices regarding their demand for desalinated and potable water, carbon-neutral liquid transportation fuel and carbon-negative sequestration in fiber-reinforced composite lumber, both made from carbonate dissolved in seawater, and for recycling the carbon in power plant flue exhaust for the storage of renewable energy such as off-peak wind power. The relative beauty, elegance, and simplicity of the possible solutions to such problems are subjective, and might involve strong differences of opinion between outside observers, mathematicians and engineers involved with the details, and fossil fuel barons, respected and enriched by society for their part in



meeting energy demand. (See "All Chemistry Equations" in 2034: Equations.) Although the original market-focused primary use of ticker tape may be a lost art, the economy is still driven by individual free will leveraging self-interested behavior to achieve social gains for civilization.

## #2208: Drone Fishing

*September 27, 2019*



MY HOBBY: DRONE FISHING

Today's consumers who order their drones off the internet don't know the joy of going out in nature and returning with a drone that you caught yourself, whose angry owners you fought off with your own two hands.

## Explanation

Another comic in the My Hobby series.

This comic is a parody of the traditional activity of fishing for fish. Typically, a person who is fishing will sit as Cueball does in this comic, by some body of water and wait for a fish to bite their cast line. However, some fisher will use a kite to allow them to cast their line further in the water, and this is called "Kite fishing". But it is also possible to use drones for this, as in "drone fishing."

Randall, however, is interpreting "Drone fishing" not as fishing with drones but as fishing for drones ("drone fishing" as in "lobster fishing"). In fact, what Cueball (or Randall) is doing, is kite fishing for drones, by flying a kite with fishhooks attached over some drone enthusiasts in hopes of snagging their drones. This is quite likely illegal, especially if Cueball were to "reel" the caught drone in.[citation needed] It seems like he has already caught two that lay in front of his feet. All the drones are of the quadcopter type, as they are called in 1630: Quadcopter.

The title text parodies a common line about fishing, about the "joy of going out in nature", catching fish, and the struggle of reeling in large fish. However, instead of being about fishing, Randall has replaced the line to be about catching drones and fighting off their owners. Considering that the two drone owners beneath his kite

are children, Jill, and a Cueball-like kid, clearly smaller than Cueball/Randall in the chair, this should not be so tough in the pictured case.

Real life methods for capturing drones involve French Army falconry training of golden eagles (a technique abandoned by Dutch police) and firing nets from other drones, which has been proposed for orbital debris removal, or the use of nets hanging on counter-drones.

A similar setup for catching bats with hooks on a kite string have been used, although it's illegal. It seems unlikely that Randall has had this in mind when he made this comic though.

## #2209: Fresh Pears

September 30, 2019



I want to sell apples but I'm still working on getting the machine to do the cutting and grafting.

## Explanation

Here, Beret Guy has set up a machine advertising "fresh pears". Megan, presumably his first customer, has inserted her quarters into the machine for the specified price, and expresses concern that the pears aren't being dispensed; Beret Guy simply assures her that "it takes a while to work".

Behind the front of the machine, thus hidden from Megan, we see that what the machine does is dispense a seed into the dirt via a small cannon. Above it is a robotic arm and a hopper for collecting and dispensing the ripened pears. So it seems that Megan will have to rattle the coin-slot "a while" before she gets her fresh pear.

The term "a while" is ambiguous, but in the context of waiting for a vending machine to dispense food, it's usually assumed to be a matter of seconds.[citation needed] Beret Guy, in his typical surrealist approach to business, seems to consider it reasonable to wait at the machine for years until a tree has sprouted from the dispensed seed, grown to maturity and begun bearing fruit, that could be picked by the robotic arm and dispensed to the buyer. This could easily take between 5-8 years for a pear tree, when starting only with a seed! While such a pear would indeed be "fresh", it's implausible that anyone would accept that kind of lag time in buying a pear at a vending machine, even if it is cheap, particularly considering that any number of factors could interfere with the production of pears in

the meantime.[citation needed] Alternatively, Beret Guy may be planning on using time-altering abilities to rapidly grow the tree.

It appears that the coin mechanism only operates the seed-launcher; whether once the machine starts harvesting the pears it will freely dispense them or activate a barrier on the chute is unknown.

This comic strip may be based on a fable about an old man who plants trees, knowing that he will not be alive when they bear fruit, to "pay it forward" to his children as his ancestors planted the trees that had sprouted and fed him. Beret Guy may be practicing good moral behavior and ecological stewardship, but as a customer-facing business model it leaves a little to be desired.

It seems Megan is one of the first to use the machine, as no pear sprouts are shown behind the machine.

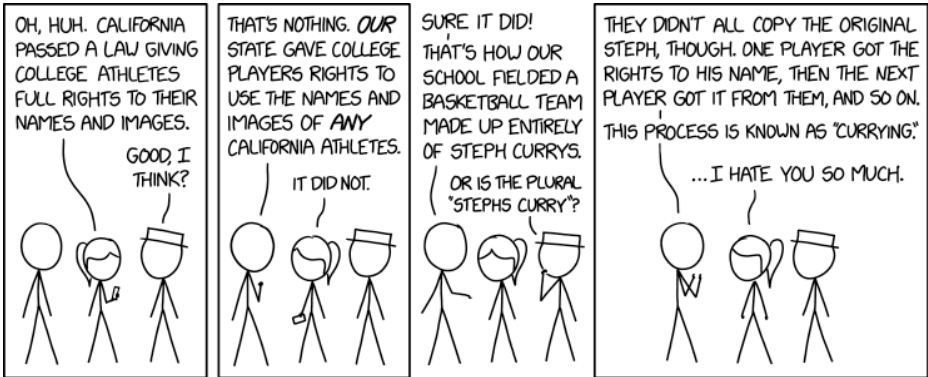
The title text refers to the increased difficulty in cultivating desirable apples, as compared to other fruits. Apples cannot be reliably produced from seeds, seedlings often don't survive, and even when they do, they don't generally reflect the characteristics of the parent plant. As a result, apple orchards are created by grafting tissue from desirable trees onto suitable rootstock. This process is more complex and labor-intensive than simply planting seeds. The joke, then, is that the next planned version of the machine would not only require the user to wait years, but would also involve as-yet unavailable

technology to automatically perform the grafting process as to create an apple tree that produces desirable fruit.



## #2210: College Athletes

October 02, 2019



Their signature play is the three-point combinator, a recursive offense which is guaranteed not to halt and continues accumulating points until the buzzer.

## Explanation

Ponytail is reading from her phone about the California Fair Pay to Play act, which was signed into law on September 30, 2019, two days before this comic was released. It gives college athletes the rights to their name and image (face, body, etc.) for financial gain, in contrast to NCAA rules which require that athletes be unpaid. This bill threatens the NCAA's notion of amateurism, which has become a topic of public debate.

White Hat thinks this law is a good thing, but then Cueball claims that his state has passed an even better law giving college players rights to the names and images of any California athletes. Note that Cueball's state is thus not California, so it is very odd they can use names from another state, in addition to the oddity of gaining rights to another person's name and image.

Ponytail doesn't believe Cueball, but he carries on claiming that all members of his school's basketball team thus have changed their name to Steph Curry after the NBA player who plays for the Golden State Warriors, a team in California. Cueball explains in particular that only one player copied the name from the NBA player, then another member of the team copied the name from that player, and so on.

As it turns out, in his final remark, all this has only been the setup for his grand joke: Cueball tells Ponytail and White Hat that this process of recursive name usage is

known as "currying". In addition to a pun with basketball rules against carrying, avoidance of which often involves passing from one player to another, this is also a play on both the basketball player's name "Curry" used here, as well as the mathematical procedure called currying, named after mathematician Haskell Curry. This sort of humor is very typical of Cueball, leading Ponytail to state that she "hates him".

Currying is when a multi-variable function is broken down into a sequence of single-variable functions, each of which outputs a new function until the final variable is consumed. For example, the function  $f(x,y,z)$  can be curried into  $f(x)(y)(z)$ , where  $f$  is a function that consumes  $x$  and produces a function  $f(x)$ , which in turn consumes  $y$ , yielding the function  $f(x)(y)$ , and that in turn is a function  $f(x)(y)$  which consumes the parameter  $z$  to finally produce  $f(x)(y)(z)$ , which is equal to the original  $f(x,y,z)$ . This is not commonly used in most areas of math except for foundational logic but it is widely used in functional programming.

When Cueball says a team made up entirely of Steph Currys, White Hat questions what the plural form should be, and should it instead have been "Stephs Curry"? This is referring to the pluralization of phrases where a noun is followed by a modifier of some sort, such as attorneys general, parts unknown, heirs apparent, mothers-in-law, and so on. In these cases, plurals are formed by pluralizing the noun parts of the phrases; however, some of these are rare or foreign enough that speakers of English don't always identify them correctly

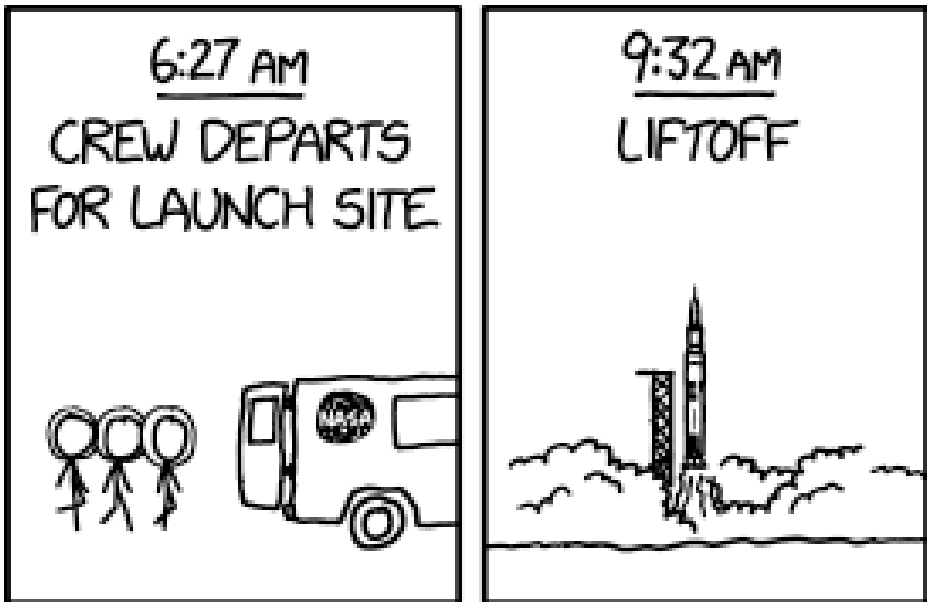
and pluralize the last word instead, e.g. attorney generals.

The title text is a computer science joke, saying that the Steph Curry's basketball team's signature play is the "three-point combinator", a joke on the three-point play in basketball, and a type of fixed-point combinator called the Y Combinator, introduced by Haskell Curry, and not to be confused with the company of the same name. The description of "three-point combinator" is dense with word play that relates to the Y Combinator, which is used to implement recursive methods in functional programming languages, has notable properties relating to halting (see: the halting problem), and has a common form in which a second argument is used as a counter that is increased by one with each recursive call until termination. "Signature play" may also be a play on words, as currying transforms a method signature.

In this case, when this move is performed, it will just keep accumulating points, as it is guaranteed it cannot halt and will not stop until the time runs out and the buzzer that ends the game is activated. Such a move can of course not be a part of a real basketball game, and more of a nod to the Golden State Warriors' reputation as a high-scoring, nearly-unstoppable offense widely known for three-point shooting.

## #2211: Hours Before Departure

October 04, 2019



I KNOW I TEND TO ARRIVE TOO EARLY AT THE AIRPORT, BUT IT STILL WEIRDS ME OUT THAT NEIL ARMSTRONG LEFT FOR THE LAUNCH SITE JUST THREE HOURS BEFORE DEPARTURE.

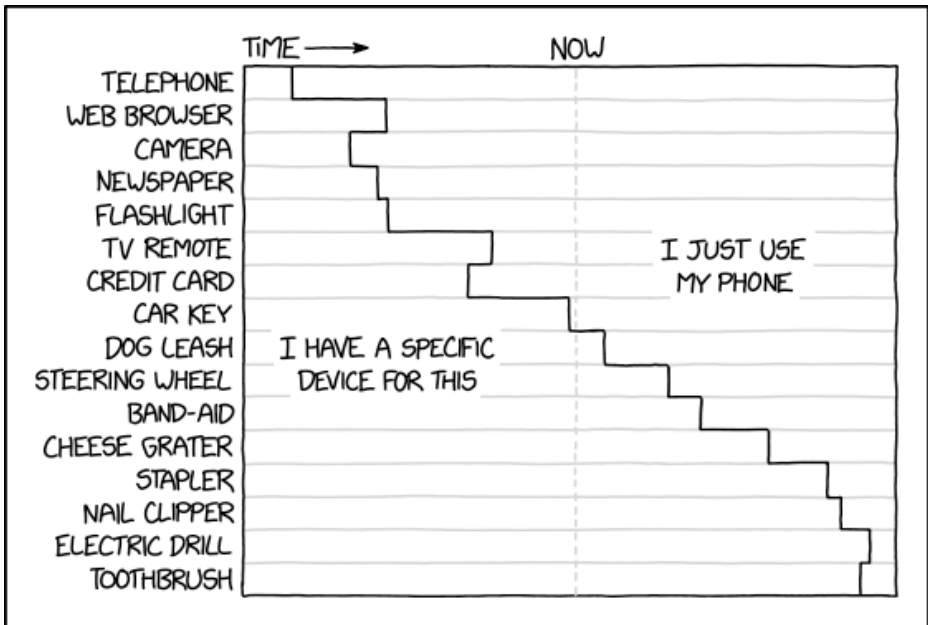
They could afford to cut it close because they all had Global Entry.

## **Explanation**

Explanation section not found.

## #2212: Cell Phone Functions

October 07, 2019



... tazer ... fire extinguisher ... bird feeder ... toilet paper ...

## Explanation

This comic pokes fun at the ever-increasing function of smartphones and their users' reliance on them through an unusual horizontal bar graph showing what services a smartphone provides (or will provide) that were performed by other devices in the past and when the switch took or will take place. It starts sensibly: Calling, browsing the Internet, and taking pictures are the most prominent examples of tasks that many if not most people use a smartphone instead of a specific device nowadays. The next item, newspaper, extends the Internet's capabilities (either from within the mobile browser or as a dedicated app), and the next, flashlight, repurposes the phone camera's flash unit; both are now commonplace features of smartphones. Some people even use their smartphone as the remote for their TV (either via RF wireless [e.g., WiFi] for smart TVs, or via their phone's infrared port) or to pay in stores using payment providers like Google Play Wallet, Samsung Pay, or Apple Pay, which utilize the near-field communication functionality of modern smartphones. A few cars now support using a phone app instead of a key fob, rendering yet another item obsolete; apparently, Randall just started using this feature in his car, as this item is in the very recent past in the comic's diagram.

Then the comic drifts off into smartphone capabilities either not yet possible or likely never to be possible. These capabilities are right of the "now" mark, meaning Randall has not switched to using a smartphone for

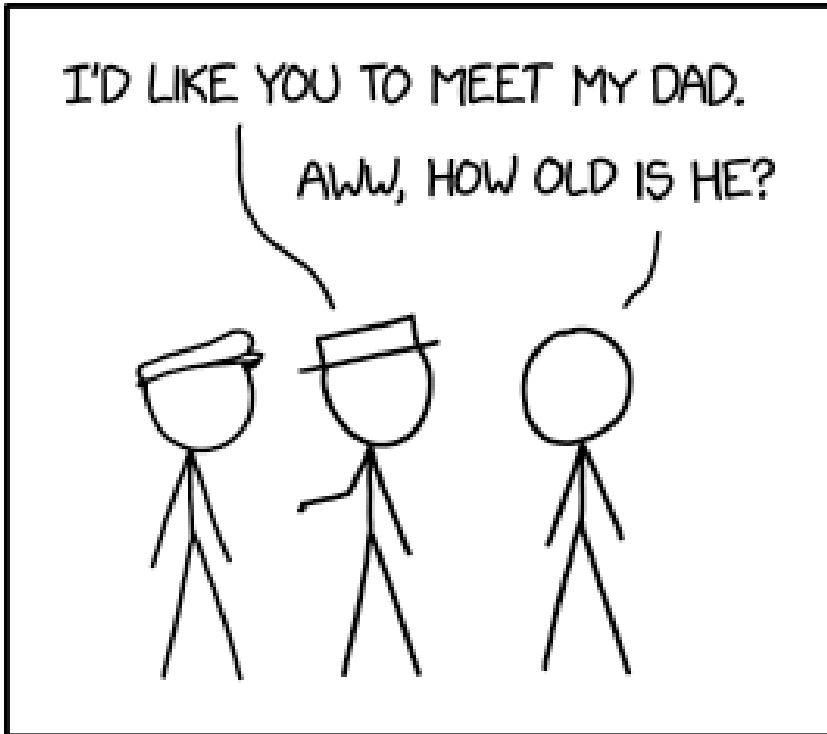


them: One cannot currently use a phone app as a dog leash, nor as an adhesive bandage. While using a phone as a steering wheel is possible (likely interfacing with the car's self-driving features), it would be a reversal of current initiatives to prevent drivers from using cell phones while driving. Things get increasingly odd, to the point where a smartphone is allegedly used as a toothbrush. Several items would require physical changes to the phone and not just repurposing existing capabilities, such as operating as a cheese grater, stapler or nail clipper, which would make the phone look and feel more like a Swiss Army Knife instead.[citation needed]

The title text continues this path by continuing the list of objects his phone will supposedly replace. These include a taser, a fire extinguisher, a bird feeder, and toilet paper, continuing the path of absurdity the comic implies with its supposed future uses for a phone.

## #2213: How Old

*October 09, 2019*



INTERACTION TIP: THIS IS A COMMON QUESTION TO ASK PARENTS ABOUT THEIR KIDS, BUT FOR SOME REASON IN THE OTHER DIRECTION IT'S WEIRD.

We've met! I remember you when you were thiiiiis tall!  
[\*holds a hand an inch above their head\*]

## Explanation

This is another one of Randall's Tips, this time a Interaction Tip, useful for people who like Randall has problems with social interactions.

White Hat introduces his dad to Cueball, who then expresses a reaction more typical of people being introduced to children, by saying Aww, how old is he?

When introduced to a young kid, saying "aww" is accepted as normal, because the speaker thinks the little child is cute. The speaker also wishes both to know the age of the kid and to give the kid a chance to answer this question.

But when meeting someone older this would feel very awkward, and Randall, indicating he is very awkward around other (normal) people, continues to make this type of comic about problems with social interactions. Hence for others with his problems, this comic gives an interaction tip in the caption, letting you know that How Old? (the title of the comic) is a common question to ask only when introduced to kids, not to older people such as elderly parents. Another excellent example of how Randall also doesn't know how to speak with people with children can be seen in 1650: Baby.

In the title text, Cueball continues down the road to awkwardness by saying other things normally reserved for meeting kids. Here he notes that he has actually met

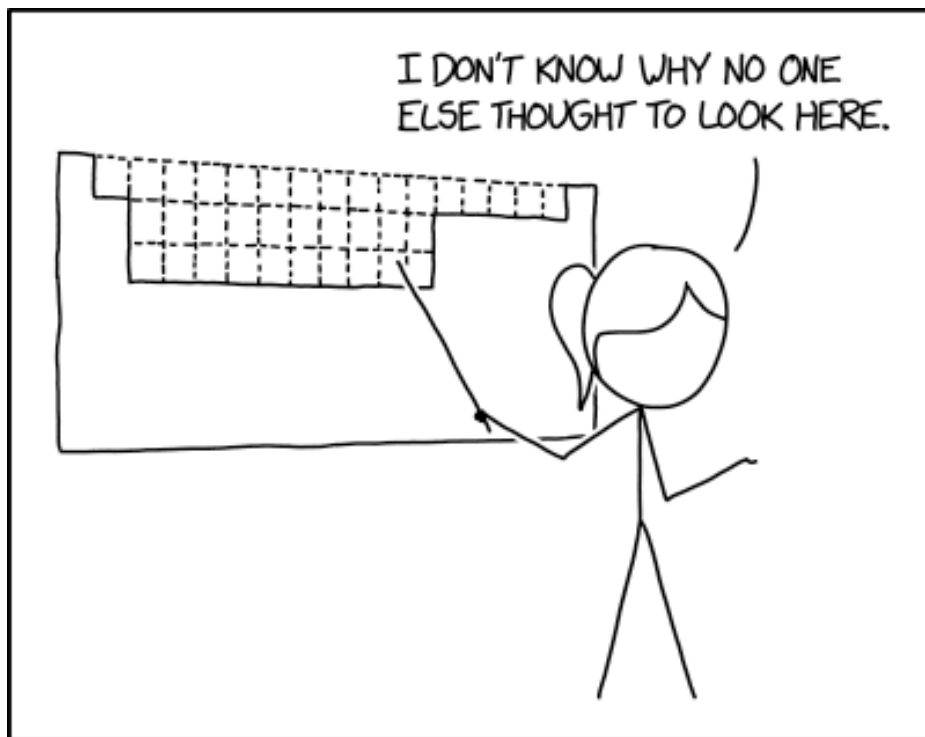
White Hat's father before, but so long ago that he since has changed height. For kids this usually means they have grown taller, but old people, who have long stopped growing, will over time become more compressed and lose height. So apart from saying that he remembers when White Hat's father was thiiiiis tall, he also holds his hand an inch (2–3 cm) above the father's head to indicate this age-related height loss. For a growing child, he would instead have held his hand some distance below the top of their head.

This interaction would be really embarrassing for White Hat and his father, as being made aware of aging is usually not something people like to be confronted with by someone they hardly know, and being treated like a child is embarrassing.

White Hat's father is wearing a sailor cap like the old version of Cueball in 572: Together and as other old people both in 586: Mission to Culture and 1910: Sky Spotters.

## #2214: Chemistry Nobel

October 11, 2019



THE 2019 NOBEL PRIZE IN CHEMISTRY WENT TO THE TEAM THAT DISCOVERED THE ELEMENTS IN THE BIG GAP AT THE TOP OF THE PERIODIC TABLE.

Most chemists thought the lanthanides and actinides could be inserted in the sixth and seventh rows, but no, they're just floating down at the bottom with lots more undiscovered elements all around them.

## Explanation

The periodic table of the elements is a display which arranges all of the 118 (currently) known chemical elements by atomic number and sorts them into columns such that each column contains a group of elements displaying similar chemical properties. The original version of this table was developed by Russian chemist Dmitri Mendeleev in 1869, when he realized that certain properties repeated periodically as elements became more massive. Notably, this system left obvious gaps at the top of the table. Mendeleev correctly predicted that some of these gaps represented elements that had not been discovered yet, and even predicted their properties based on the patterns in the table. The later discovery of those elements (including germanium and gallium) helped validate Mendeleev's work. Other gaps, however, were not due to undiscovered elements, but merely resulted from the properties of electron orbitals in atoms: upper rows of the table represent orbitals with fewer possible electrons and hence fewer elements, so displaying the lower rows properly below the upper ones leaves gaps in the upper rows. In other words, elements could not actually exist in these spaces, spaces which only existed in the realm of human bookkeeping. The joke of this comic is that it treats these gaps as if they represented elements that hadn't been discovered yet. Ponytail and her team have won the Nobel Prize in Chemistry merely by looking for and finding these elements. She expresses surprise that no one else had thought of such a simple

direction for research.

By definition, each element has one more proton than the previous element - so element 1, hydrogen, has one proton in the nucleus, while element 2, helium, has two protons in the nucleus. The periodic table represents elements in their atomic form, where there are an equal number of protons and electrons (as opposed to an ionized form where they are unequal), so the structure of the periodic table is based on the structure of the "orbitals" that electrons fall into.

The first row of the periodic table has elements whose electrons only have an "s orbital" (at least when the electrons are in their ground state, which is the non-excited state that they are normally in). There is only one s orbital in each row, and an s orbital only has room for two electrons, so there are only two elements in the first row. The Pauli exclusion principle, mentioned in xkcd 658, means that only two electrons can be in each orbital. The second row of the periodic table contains elements with only s and p orbitals. As mentioned, there is only one s orbital at each "level" of orbital, with each level basically corresponding to a row, but there are three p orbitals at each level, so there can be four total pairs of elements in the second row, for eight total elements in the second row. (You can see that level one has a total of  $1^2$  orbitals, or 1 orbital, while level two has  $2^2$  orbitals, or 4 orbitals.) After p orbitals, the next type of orbital that can exist at higher levels is a d orbital. For levels that have a d orbital, there are five d orbitals at each level. Beginning with the fourth row, you can see elements

whose highest-energy electrons are in an s orbital (the first two columns), a p orbital (the last six columns), or a d orbital (the middle ten columns). The d orbitals for row four are actually classified as the 3d orbitals (meaning they belong to level three), but because they have higher energy than the 4s orbital, they are put on the fourth row. The "aufbau principle" says that electrons fill the lowest energy orbitals first, which means that level one orbitals get filled before level two orbitals, which get filled before level three orbitals, and that within each level the s orbitals get filled before the p orbitals. So, there are two columns on the periodic table for each orbital - although helium is put in the far right instead of in the second row with the other elements whose highest electron is the second one in an s orbital, because putting it on the far right shows that helium is stable like the other "noble gases" in the far right row.

The final type of orbital that exists as the ground state for a known element is the f orbital, but almost all periodic tables show the elements with their highest electrons in an f orbital - the lanthanides and actinides that are mentioned in the title text and described below - in rows below the table, to prevent the table from becoming too wide to print easily.

The comic is based on the joke that somehow every physicist and chemist for generations somehow missed that there are actually p and d orbitals at levels one and two, and so it shows the empty space in the columns corresponding to the p and d orbitals in level one and the d orbitals in level two being filled with undiscovered



elements. In reality, there are no p or d orbitals at the first level and no d orbital at the second level, due to quantum mechanics (involving the possible values of something called the quantum n, l, m, and s numbers, where n is the level and l determines whether is an s, p, d, or f orbital). The comic also shows a line of d orbital elements in the third row, even though the 3d orbitals are already represented in the fourth row (where they are placed due to having higher energy than the level 4 s orbitals). The Pauli exclusion principle has been known since 1925, and Mendeleev (mentioned in xkcd 965) developed the structure of the periodic table in 1863 to describe the structure of the known elements, so the idea that such a basic thing as more elements in the early rows that had never been discovered by any chemist ever would be quite surprising. In reality, the elements toward the top of the periodic table that are known to be naturally occurring were generally discovered earlier, while all the most recently discovered elements are higher-numbered elements lower down on the table that are very short-lived before they undergo radioactive decay to another element and have never been seen to be naturally occurring.

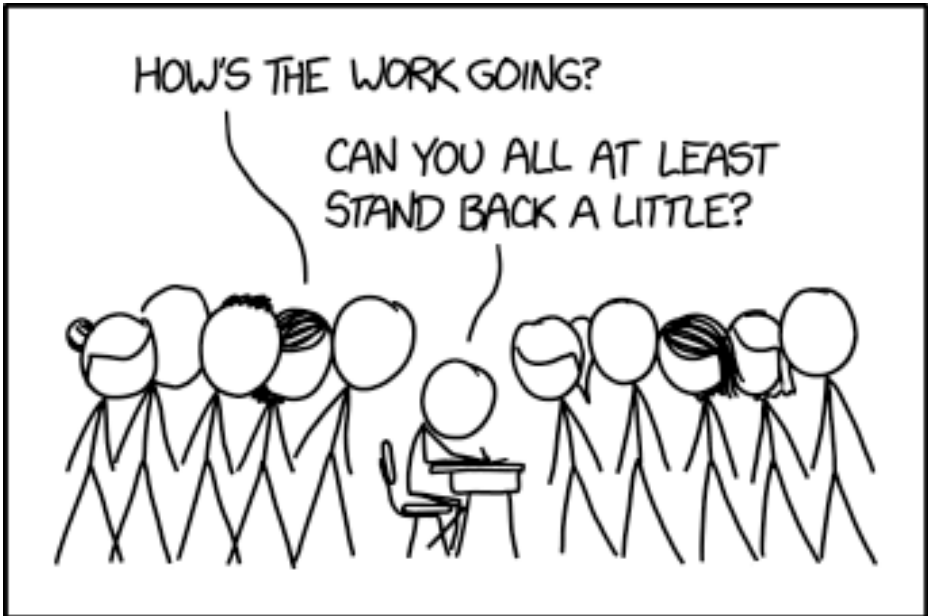
The lanthanides and actinides mentioned in the title text are series of elements with higher atomic numbers that have electrons in orbitals that no previous elements have, and thus occupy columns of the periodic table that don't exist for lower-numbered elements. Sometimes these elements are displayed in the table, a format that corresponds with their actual orbital structure; this

format is too wide for most display media, thus the lanthanides and actinides are separated out and displayed "floating" beneath the rest of the periodic table. The title text jokes that these floating series of elements are actually surrounded by actual elements.

In real life, the 2019 Nobel Prize in Chemistry was awarded to John B. Goodenough, M. Stanley Whittingham, and Akira Yoshino for their work in the development of lithium-ion batteries; it was announced on October 9, just a few days before this comic was published, so the chemistry Nobel Prize was in the news.

## #2215: Faculty:Student Ratio

October 14, 2019



MY SCHOOL TRIED TO GAME THE RATINGS  
BY HAVING A 30:1 FACULTY:STUDENT RATIO

They managed to briefly hit the top of the rankings when they rejected everyone except one applicant, published 5 billion research papers that just said "Hi," and hired one of their graduates for \$50 trillion/year (then fired them after 10 microseconds.)

## Explanation

Universities are often rated in various ways to help students/parents pick which one to attend. This comic satirizes the very real culture of schools modifying their actions to artificially inflate their ratings. One metric used in ratings is the ratio between the number of faculty members to the number of students. Typically this is expressed as the student-teacher ratio, which normally determines how much time teachers get to spend with individual students. The lower the ratio, i.e., the fewer students per teacher, the smaller classes teachers have to teach, and thus the more attention the teachers can give to each student. However, having many more teachers than student(s), as in this comic, is not very beneficial to the student(s). (For context for international readers, high student-teacher ratios are common and expected in the United States, Randall's home country, whereas some nations especially in Asia sometimes report much lower ratios, often close to 1:1 in some areas.)

Another metric commonly used to measure a college's exclusivity and therefore prestige is the college's rejection rate; more prestigious schools get more applicants, and since they can accept only a limited number, they must reject many. Less prestigious schools often accept a higher fraction of their applicants, but some schools will reject students whose test scores, résumé, etc. are much higher than average for the school since it's likely that college is a "safety school" and the student won't actually go there. This rejection can decrease the school's

acceptance rate and make it appear more prestigious. However, if the above-average student does want to attend that school, they are unable to, even though it would be good for both the college and the student.

For-profit universities and diploma mills may use techniques like this to artificially boost their ratings or use fabricated metrics and accreditation mills to give an inflated appearance of value. Predatory publishers and conferences are other techniques used to inflate the perceived value of a school or to pad curriculum vitae.

In the title text, other metrics are skewed in the school's favor:

- Having a high standard for entry is usually associated with better or high-prestige schools; however, this is subverted by the fact that the school has only one student per class. A class of one would make (at least for most students) for a poor educational experience,[citation needed] especially in this case, where the student is apparently being micro-managed by all of the teachers at once. Even if it were a good academic environment, it could only benefit one student per year, which means the school would only have a very modest impact on the world.
- A high number of research papers would normally indicate a high level of scientific research at the school; however, these research papers have no real content in them and are all identical, rather missing the point of a research paper - namely, to make the scientific

community aware of new research.

- A high hiring rate (percentage of students that have gotten a job after education) and a high average salary after graduation is favorable, as it is one goal for many students attending college. However, the school in question artificially inflates these metrics by having all (one out of one) of their student body be hired by them, producing a 100% hiring rate, and giving them a starting salary that is astronomically high, but not giving them enough employment time to actually gain very much income. \$50 trillion/year for 10 microseconds is approximately \$15.85 ( $= \$50e12 / (365 * 24 * 60 * 60) * 10e-6 * 10$ ) if pay is assumed to be spread constantly over the full 365 days of the year. Assuming fifty-two 40-hour workweeks would make this \$66.77. Since xkcd originates in the USA, and a later comic describes short scale as "normal" vs long scale as what an "old British person" would use, trillion most likely means  $1e12$  (i.e., short scale), as compared to  $1e18$  (long scale interpretation).

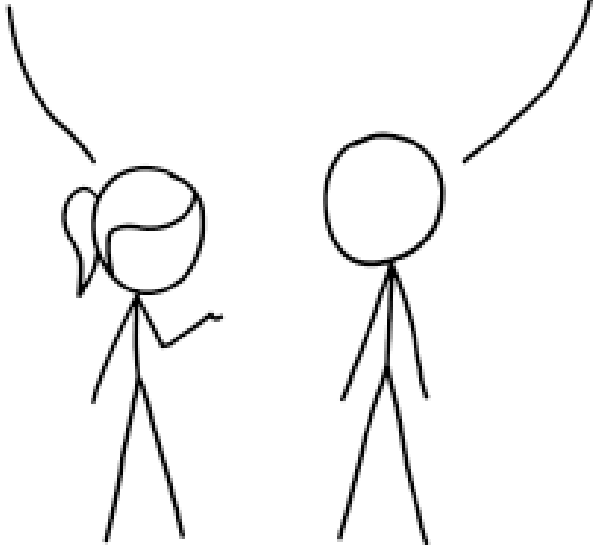
## #2216: Percent Milkfat

October 16, 2019

"2% MILK" IS 2% MILKFAT. BUT "WHOLE MILK" ISN'T 100% MILKFAT—IT'S 3.5%.

WEIRD. WHAT'S THE REST OF IT?

ABOUT 27% IS DARK MATTER.  
THE REMAINDER IS DARK ENERGY.



"So what's dark energy?" "Cosmologists and the FDA are both trying very hard to find out."

## Explanation

While cow milk contains a variable amount of fat (about 4.2%), whole milk from the store generally contains about 3.5% milkfat by weight according to the comic and some sources; other sources list similar but not identical numbers such as 3.25%.

Dairies commonly sell whole milk as well as products with less fat produced by removing milkfat. In the United States, there are three common products with less fat: 2% or "reduced fat" milk, 1% or "lowfat" milk, and "fat-free" or "skim" milk with 0 to 0.5% milkfat.

Since whole milk is labeled as "whole" milk and not as "3.5% milk," one might naively assume that whole milk is 100% milkfat, although this is not the case; 100% would be a product which is entirely milkfat (also known as butterfat), such as clarified butter or ghee. In milk, the remainder is mainly water along with proteins, lactose (a sugar), and other substances.

The comic analogizes this difference to the fact that physicists believe that "ordinary" matter constitutes only 5% of the actual mass-energy of the universe. Scientists predict the existence of another kind of matter known as "dark matter," invisible to our current instruments but exerting gravitational force on ordinary matter, which would constitute 85% of total matter and 27% of the universe's mass-energy, with the remainder an even less detectable and more mysterious "dark energy"



accounting for the increasing speed of expansion of the universe.

Ponytail uses these quantities to "explain" the "missing" percentage in whole milk between the actual 3.5% and a potential 100% "whole." She actually uses the 27% as mentioned above for dark matter. She thus indicates that dark energy takes up the remaining 69.5% of the whole milk.

Ponytail is assuming that dark matter and dark energy are distributed uniformly throughout all pockets of the universe, no matter how small. This assumption is common in statistics and may have seemed appropriate since no one knows the proportion of dark matter or dark energy of an object as small as a milk carton (though a more sensible argument is that all matter is accounted for when considering the milk and the carton; no additional "dark" matter is necessary to explain the weight of the milk carton).

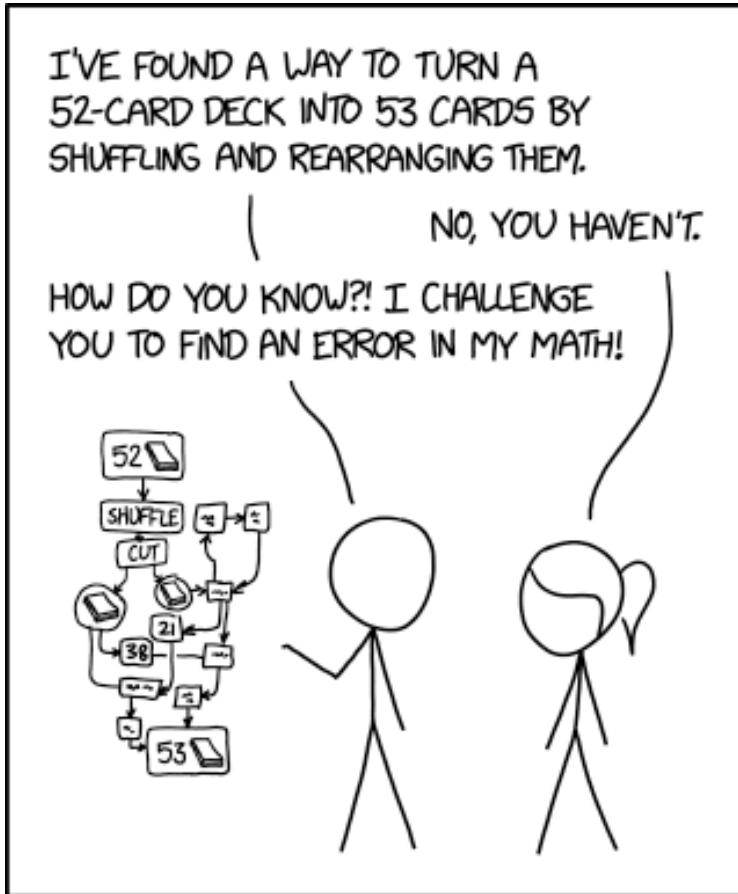
Cosmologists are working to better understand dark energy or another reason for the universe's accelerating expansion. The title text supposes that both cosmologists and the Food and Drug Administration (FDA), which regulates milk and other food items in the United States, are trying to understand the dark energy of the whole milk. In real life, the work of cosmologists and FDA scientists does not overlap at all.[citation needed]

Dark energy was recently mentioned in 2113: Physics Suppression, but before that milkfat and dark energy

were actually mentioned in the same sentence in 2063: Carnot Cycle from almost a year before this comic, so the idea behind this comic is not new for Randall. Dark matter was mentioned back in 1758: Astrophysics and 2186: Dark Matter.

## #2217: 53 Cards

October 18, 2019



EVERY CONVERSATION BETWEEN A PHYSICIST  
AND A PERPETUAL MOTION ENTHUSIAST.

Well, there's one right here at the bottom, where it says "53."

## Explanation

In this comic, Cueball claims that he has found a way to manipulate a 52-card deck into a 53-card deck by shuffling and rearranging the cards, presenting a complex-looking diagram to support his claim. Ponytail naturally disputes the claim immediately, which Cueball counters by challenging Ponytail to prove that his math is wrong.

The comic is a satire of the way that conversations tend to go between physicists and perpetual motion enthusiasts (or cranks in general). Perpetual motion is the idea that it could be possible for a mechanical system to work indefinitely without any external input of energy. The laws of thermodynamics absolutely prohibit this, so the only way that this could be possible is if the laws of thermodynamics are wrong. Unfortunately, the laws of thermodynamics are some of the most foundational and well-tested laws in science, so perpetual motion is considered to be a pseudoscience, pursued only by ignorant or quixotic cranks.

One of the things that you could do with a perpetual motion machine is to violate the law of conservation of energy - that is, you could create free energy out of nothing, simply by building a mechanical device. This is likely what Randall is satirizing with the idea of a process that can generate an extra card out of nowhere - it makes no physical sense, but nonetheless Cueball is convinced that he has found a way to do it.

A common defense employed by pseudoscientists, when challenged on their ideas, is to issue a counter-challenge and demand people prove them wrong, as Cueball does in this comic. This is a fallacious line of argument, since the fact that Ponytail cannot prove Cueball wrong does not mean that he is right. Nonetheless, this aggressive defense often works to discourage argument, since it takes far less effort to make a claim than to refute it.

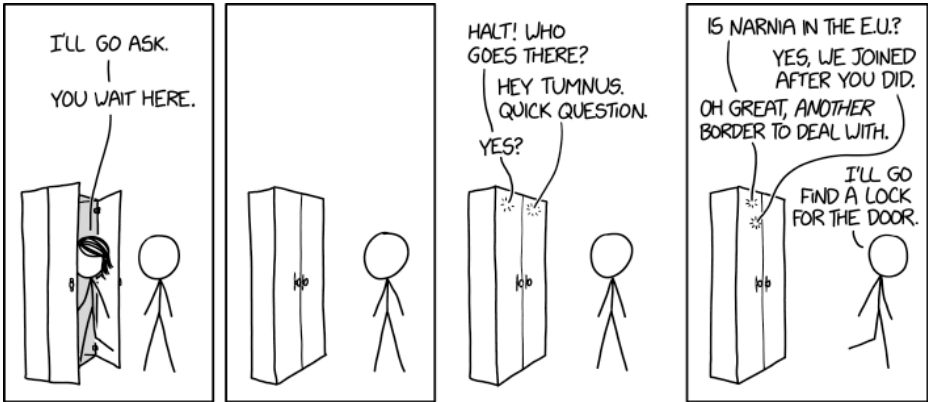
Possibly, Cueball's plan involves usage of the Banach-Tarski paradox, a mathematical theorem which describes a method of "dismantling" a solid sphere, rearranging the component pieces, and reassembling them into two solid spheres identical to the original. This is only possible in a mathematical ideal case, because the "component pieces" are actually dense sets of points; every neighborhood, however small, contains points of multiple pieces. Such a procedure cannot be performed on playing cards, which are discrete (zooming far enough into a single card, you get a neighborhood containing only that card and no others). Cueball's operations of shuffling and rearranging are analogous to the operations used in the Banach-Tarski operation, which involves only moving and rotating the component pieces without changing their shape. The Banach-Tarski paradox was also referenced in 804: Pumpkin Carving.

In the title text, Ponytail responds to Cueball's challenge with snark, claiming that the most obvious error is the fact that the formula's result is "53". The implication is that his math results in the wrong answer, which is proof that the calculations must contain errors. This, of

course, starts with the assumption that Cueball's claimed result is impossible, rather than attempting to find the flaws in his specific method. Because most people would conclude, by basic physical reasoning, that merely shuffling and rearranging a deck of cards cannot increase the number of cards in the deck, that feels like a safe assumption. By analogy, increasing the amount of energy in a system only by moving and transferring energy should be equally impossible, on its face.

## #2218: Wardrobe

October 21, 2019



If you'd just agree to hold your meetings in here, you'd have **PLENTY** of time to figure things out before the deadline.

## Explanation

This comic references *The Chronicles of Narnia*, a series of children's fantasy books by C.S. Lewis (some of which were later made into movies, plays, and TV and radio shows) about a group of children from England who travel to a magical land called Narnia. In the first book of the series (by publication date), *The Lion, the Witch, and the Wardrobe*, Narnia is accessible through a wardrobe in a residence in the English countryside. Mr. Tumnus is a faun in Narnia and the first character that the first human visitor, Lucy Pevensie, meets on her first trip through the wardrobe portal. Referencing Narnia is a recurring theme in xkcd. Tumnus was depicted in the first comic to reference Narnia: 665: Prudence.

The comic also makes reference to membership in the European Union. The United Kingdom (UK) is a member of the EU at the time of this comic, but narrowly voted via public referendum in 2016 to exit the EU (a process commonly referred to as Brexit, portmanteau for Britain/British and exit), but working out the details of this separation has proven more complicated than the simple in/out vote implied.

Narnia applying to join the EU shortly after the UK, as referred to in the title text, would theoretically be possible, even if only *The Lion, the Witch and the Wardrobe* was considered, since the UK joined the EU in 1973, whereas the wardrobe entrance to Narnia was discovered during World War 2, therefore in the period



between 1939 and 1945. However, they would most likely be rejected due to not technically existing in Europe and having a monarchy government (EU membership requires a stable democracy).

One of the major issues with Brexit remains the border between Northern Ireland and the Republic of Ireland. The two countries share the island of Ireland, but Northern Ireland is part of the UK while the Republic is an independent country which remains part of the EU. With the UK exited from the EU, it would have different customs regulations than the Republic of Ireland, and there would need to be some kind of customs border. The most obvious solution would be to establish a controlled land border between the two countries, but this would raise some serious difficulties and dangers.

Northern Ireland has had a long history of civil unrest and ethno-nationalist conflict. The most recent period of conflict, commonly referred to as The Troubles, resulted in over 3000 deaths between 1969 and 1998. In 1998, the UK and Ireland entered into a treaty, known as the Good Friday Agreement (overwhelmingly approved by referendums in both parts of Ireland). This treaty was intended to resolve many of the issues that drove the conflict, and has largely been successful in putting a stop to the violence. One of the agreements in the treaty was a totally open border between the two parts of Ireland. As both were in the EU, this was easily done, because they already shared a customs union. Over the following two decades, the ease of transit created major trade links between the two areas, and many people lived in one

country and worked in the other. In the UK Brexit referendum, a majority of Northern Ireland voters voted to remain in the EU. Placing a hard border between the two countries would create major economic disruptions, and serious hardships for people living near the border. It would also undermine the intent of the Good Friday Agreement, which could lead to the rekindling of hostilities and the return of terrorist attacks, instead of all sides pursuing purely political means to uphold their aims of finally joining with the rest of Ireland or continuing to stay British. The Irish government raised this issue from the time Brexit was first proposed, but their warnings were not fully heeded.

The alternative to this border would be to maintain open borders between Northern Ireland and the Republic of Ireland, but institute customs checks between the island of Ireland and the United Kingdom. In October 2019, Boris Johnson, British Prime Minister, negotiated a Brexit deal with the EU that included this arrangement, but from late 2020 onwards instituted seemingly contrary rules that have not yet (as of the end of his premiership, in 2022) been resolved.

While the Northern Ireland/Republic of Ireland border issue has received the most attention, the UK has land borders with two other EU countries. The UK territory of Gibraltar shares a border with Spain. There are also two Sovereign Bases Areas that share a border with the Republic of Cyprus.

The portal in the wardrobe represents another border of

the UK, namely the border between England and Narnia. This 'border', of course, exists only in fiction, but the joke here is that it must be dealt with in the Brexit negotiations, further complicating an already messy situation.[citation needed] A further source of implicit humor is the juxtaposition of a fantasy children's tale about the magical land of Narnia with the highly contentious, political, adult world of Brexit.

Cueball suggests solving the situation by simply locking the wardrobe (which was never very accessible, even in *The Chronicles of Narnia*), effectively isolating the UK from Narnia and making the border problem moot. This wouldn't work even in the fictional world of the books, as new ways to enter Narnia pop up in every book, although most of them are accessible only to the kids from the first book and their friends.

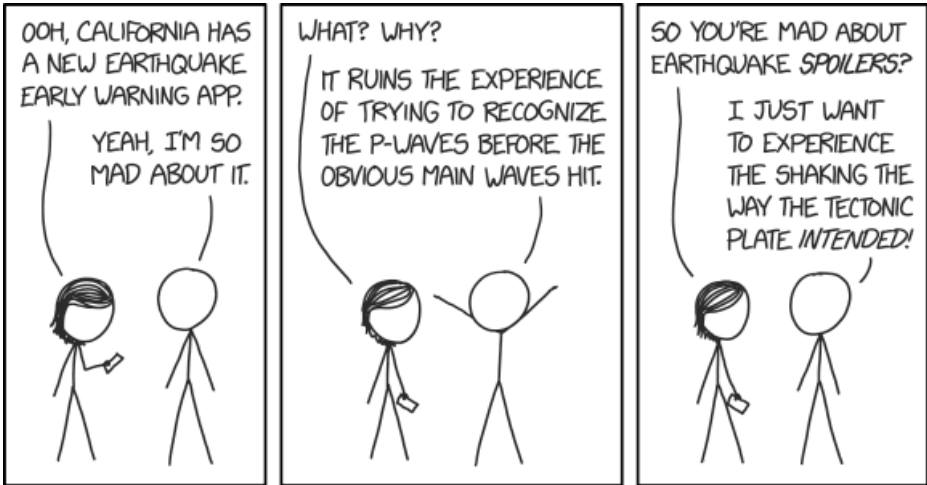
The title text references the amount of time it has taken to complete the Brexit negotiations, that was three-plus years and counting at the time of the comic, and 'completed' during Johnson's term but leaving important issues (such as the above) not fully resolved. The negotiators had set a series of deadlines to complete the negotiations, but had repeatedly had to extend those deadlines because they hadn't reached any agreement. The comic was posted roughly one week before the then-current Brexit deadline of Oct. 31, 2019. However it was already expected that that deadline too would probably be extended and while the core element of Brexit eventually 'got done', there remain a number of unresolved issues. In *The Chronicles of Narnia*, time

moves inconsistently in Narnia compared to Earth, usually passing more rapidly in Narnia than on Earth. Lucy Pevensie and her siblings enter the wardrobe as children, have extensive adventures in Narnia lasting many years, and then return to Earth to find that they are children again and that only a few minutes have passed. The suggestion here is that holding the slow, complex Brexit (and 'post-Brexit') negotiations in Narnia would take relatively little time on Earth, and the whole affair could be completed in time for any deadline.

A punchline similar to the title text, where the slower passing of time was used to take on time-intensive real world problems, was also used for one of the comics in 821: Five-Minute Comics: Part 3. The time difference was also mentioned in the title text of 1786: Trash.

## #2219: Earthquake Early Warnings

October 23, 2019



I was fired by the National Weather Service five minutes after they hired me for going into their code base and renaming all the tornado warnings to "tornado spoiler alerts."

## Explanation

A week before this comic, on October 17th, California introduced an earthquake warning system in the form of an app for smartphones called MyShake.

The system works through a network of sensors across the state that can detect P-waves from an earthquake, which move faster than the S-waves, which cause most of the damage. In addition, the sensors send the warning electronically - at a significant fraction of the speed of light - much faster than either P-waves or S-waves. Because of these differences in speed, the network can send warnings through the app about 5-20 seconds before major shaking occurs, enough time for people to take cover under tables, run outside, etc. The farther you are away from the epicenter, the more warning time you have.

In the comic Megan talks about the app, suggesting how cool it is, but Cueball is upset. He seems to think that prediction of the earthquake coming is like a spoiler that ruins the experience of how an earthquake should be experienced. Apparently he prefers to simply be taken by surprise like most people are when an earthquake large enough to feel hits.

He also personifies the tectonic plates (whose shifting positions causes the quake), saying that we should all feel the shaking the way the tectonic plate intended. The statement is usually one regarding to arts, such as a music lover might prefer to listen to older music from vinyl

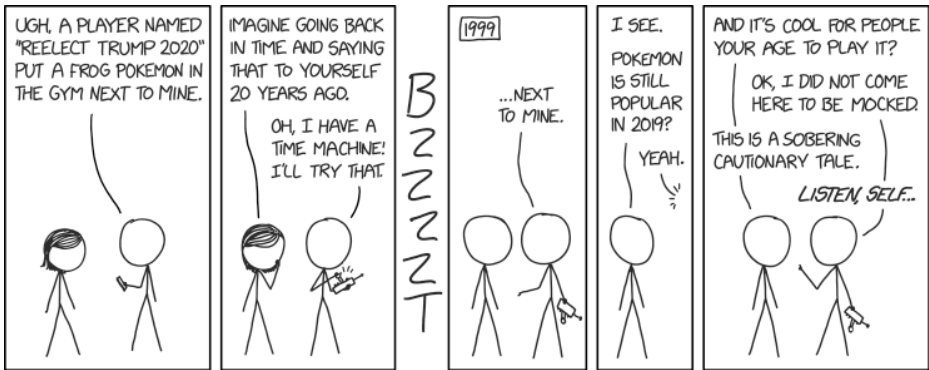
(including cracking sounds, etc.) instead of a remastered digital version, as it is, as the artist intended. Cueball seems to ascribe auteur theory to tectonic plates — a viewpoint rarely expressed in debates on either auteur theory or tectonic plates.[citation needed]

In the title text Cueball mentions that he was fired from the National Weather Service five minutes after they hired him because the first thing he did was to rename tornado warnings as tornado spoiler alerts. A spoiler alert is something used, for instance, when talking about a plot twist of a new movie, so that people who haven't seen the movie can avoid learning important details that would spoil the experience of seeing the movie. Cueball seems to genuinely wish to be surprised by these potentially lethal phenomena for which just minutes of warning may make the difference between life and death.

Earthquake warnings, on a smartphone but not as an app, were the topic of 723: Seismic Waves, and shortly before that a protip for an alternative seismograph was mentioned in 711: Seismograph. An app for warning about tornadoes was the topic of 937: TornadoGuard. Warnings in general by the NWS were the subject in 2179: NWS Warnings, which mentioned tornadoes, volcanoes, tsunamis, and many other hazards. Tsunamis are often caused by earthquakes, though earthquakes were not specifically mentioned.

## #2220: Imagine Going Back in Time

October 25, 2019



I wonder what the trendy adults in 2019 who are too cool for Pokémon will be into. Probably Digimon!



## Explanation

Cueball is checking his Pokémon Go app to check on the status of a Pokémon he had previously left in a gym (to defend it against the other two teams in the game). In the gym he sees that another player named "Reelect Trump 2020" has left a frog Pokémon, which is now standing next to his. Cueball, evidently not a fan of President Trump or his supporters, finds it distasteful to be indirectly associated with someone whose political views he finds unpleasant. Alternatively, it may simply be that Cueball doesn't want politics injected into a game that he plays for fun.

When he remarks on this to Megan, she observes how strange that remark would sound if he said it to his younger self from 20 years ago. Normally when people say, "imagine going back in time", they are merely constructing a hypothetical scenario to illustrate how rapidly society has changed over the years. Megan is likely pointing out that the idea of Donald Trump becoming the President of the United States (let alone coming up for re-election) would have seemed very farfetch'd just 20 years ago.

However, it turns out that Cueball somehow actually does have the time-travel technology required to pull this off, and so he takes Megan's suggestion literally and goes back in time 20 years to do exactly what she suggested: he repeats the statement to his younger self to see what his reaction will be.

Unfortunately, past Cueball (in the year 1999) chooses to focus on a completely different aspect of the statement: the fact that Pokémon - a game that past Cueball sees as a children's game - will still somehow be popular in 20 years, and that his adult self is still playing it. These observations make Cueball feel uncomfortable, as they highlight the fact that he is spending time on pursuits that his younger self sees as frivolous or childish. He gets defensive and starts to argue with his younger self.

When his younger self begins to call it a sobering and cautionary tale, it may dawn upon present Cueball that he may just have changed how his former self will behave. (Could he, in the new iteration, never even begin playing Pokémon Go, and thus present Cueball may disappear and a different version of himself will exist 20 years later? Or could he have seeded encouragement for himself being more readily connected to all things Pokémon in the intervening years, putting himself further ahead of the resurgence in its popularity?) Or else future-Cueball is just frustrated at how past-Cueball is failing to notice his intended revelation — and in turn is failing to appreciate past-Cueball's own naive but still insightful interpretation.

Pokémon is a media franchise that debuted in 1996 in Japan as both a video game and a trading card game. It was originally designed for and marketed to younger children (the tie-in cartoon series constantly emphasizes its main characters are ten years old), with a design, aesthetic and gameplay that were optimized for a

younger audience. Since then, and up to 2019, there have been a total of eight generations of video games on consoles. As the franchise continued to thrive and evolve, it's gone through multiple generations, including Pokémon Go, an augmented reality game for smartphones. These latest versions, in particular, have become popular with (and marketed to) adults, some of whom grew up playing the earlier generations.

In 1999 in North America, only the first generation of Pokémon video games had been released, consisting of Pokémon Blue and Pokémon Red and the anime-based spin-off Pokémon Yellow for the Nintendo Game Boy/Game Boy Color. The second generation of Pokémon video games would not even be announced in Japan until November 1999, and advertising for the North American release would begin in December of 1999. A person living in 1999, who has only seen the first generation, with no official confirmation that a second generation was even being considered, and unable to predict the nostalgia market that would appear later, would quite plausibly wonder about its popularity 20 years later.

Donald Trump was the president of the United States at the time of publishing, elected in 2016. Even during his campaign, the idea of his election was considered absurd in many circles, as he had never held any kind of public office, and had no background that would lend itself to expertise in government or public policy. Prior to his election, he was primarily known as a New York real estate mogul and host of the 2003 reality television show

The Apprentice. While he'd been teasing the idea of a presidential run since the 1980s, and indeed was seeking the Reform Party candidacy in 1999 (at the advice of then-Governor of Minnesota Jesse Ventura, another actor-turned-politician), most people did not take the idea seriously, and the concept of him actually being President of the United States would have been hugely unexpected to most Americans in an earlier era. 1999 Cueball might regard the name "Reelect Trump 2020" as an ironic joke, like a campaign button for Vermin Supreme or the Sweet Meteor Of Death.

Randall released a comic about Pokémon Go less than a week after its release back in July 2016: 1705: Pokémon Go. But Pokémon in general has been a recurring theme in xkcd long before Pokémon Go was released.

Pepe the Frog is an internet meme that has become associated with Donald Trump after his use of it during his presidential campaign. The use of a frog Pokémon, therefore, is a callback to this internet phenomenon.

The Pokémon left in the gym is most likely Politoed, the only official frog Pokémon released in the game at the time of publication. It comes from the tadpole series with Poliwhirl that evolves into Poliwag which by using a King's Rock can be evolved to Politoed (instead of to Poliwhirl). There are other frog-like Pokémon in the game which are scheduled to be added to Pokémon Go, but where people who dislike Trump might have chosen Toxicroak, it seems an unlikely choice by a fan that hopes Trump is reelected!

This comic's joke is similar to one used in the 1985 science-fiction film *Back to the Future*, in which Doc Brown (of 1955) is shocked to learn that Ronald Reagan would be the President of the United States in thirty years' time, when in 1955 Reagan was a TV actor.

Digimon, as mentioned in the title text, is another media franchise which is similar to Pokémon in some ways, though it is sometimes perceived as more "cool" and "adult" oriented. Its popularity in North America rose around 1999 with the airing of its anime series, but never became as popular as Pokémon.

This was the first of two time travel comics in less than a week, as the one two comics after this one, 2222: *Terminator: Dark Fate*, also had future Cueballs travel back to visit their past self.

## #2221: Emulation

October 28, 2019



I FEEL WEIRD USING OLD  
SOFTWARE THAT DOESN'T  
KNOW IT'S BEING EMULATED.

I laugh at the software as if I'm 100% confident that it's 2019.

## Explanation

Here Cueball is speaking with a fictitious example of artificially intelligent software similar to the type popularized in the 1980s when personal computers had just become mainstream. Although modern computing platforms might still be backwards-compatible with 8-bit era software, it is more likely that the old applications will need to be run within an emulator that can simulate the necessary hardware components required by the application.

In this case the "8-bit AI" is having a conversation with Cueball as it carries out tasks common to the era, specifically asking the user to insert a floppy disk into drive "A:" (A: traditionally being the first floppy drive on IBM-compatible PCs). At the time internal storage like a hard disk was an expensive luxury item and most applications were stored on removable media. An application that could not fit on a single floppy disk would be programmed to prompt the user to insert successive floppies which held the required data. However, the speed at which data could be loaded from such devices was very slow, requiring anywhere from ten seconds to ten minutes to load a level or an advanced dialog box. Sometimes the software would even incorporate feedback mechanisms like loading screens to let the user know the program was proceeding as intended and had not crashed.

When software operating under an emulator such as

DOSBox makes a request to access disc storage, the emulator will often map the command to a file or file system on the enveloping computing environment which can now contain hundreds or thousands of gigabytes of storage. Depending on the configuration, this may require a user action to complete the virtual operation (Cueball's click). The speed of modern hardware allows the data to be transferred at speeds several orders of magnitude higher than what was possible in the past. The 8-bit AI notices this and makes a comment about the transfer speed. Software may indeed have sometimes been designed to track the accessible rate of data, to give a rough estimate of the total loading time (or know how long it may need to animate a "while you are waiting..." display) no matter what the speed of the hardware is. This becomes less important once splash-screens or "spinning cursors" aren't (usually) expected to stay on screen for many minutes without any obvious signs of practical completion.

Here we begin to see the consequences of emulation upon the anthropomorphized software application. Because the emulator is constructing the application's entire reality, the 8-bit AI has no reason to believe it is anywhere other than a 1980s' computing platform for which it was designed. While the application does notice the abnormally fast load time, Cueball decides to not burst his anthropomorphized program's bubble and responds that the file loaded quickly because of a new floppy disk from Memorex, which was a well-known manufacturer of premium magnetic recording media in



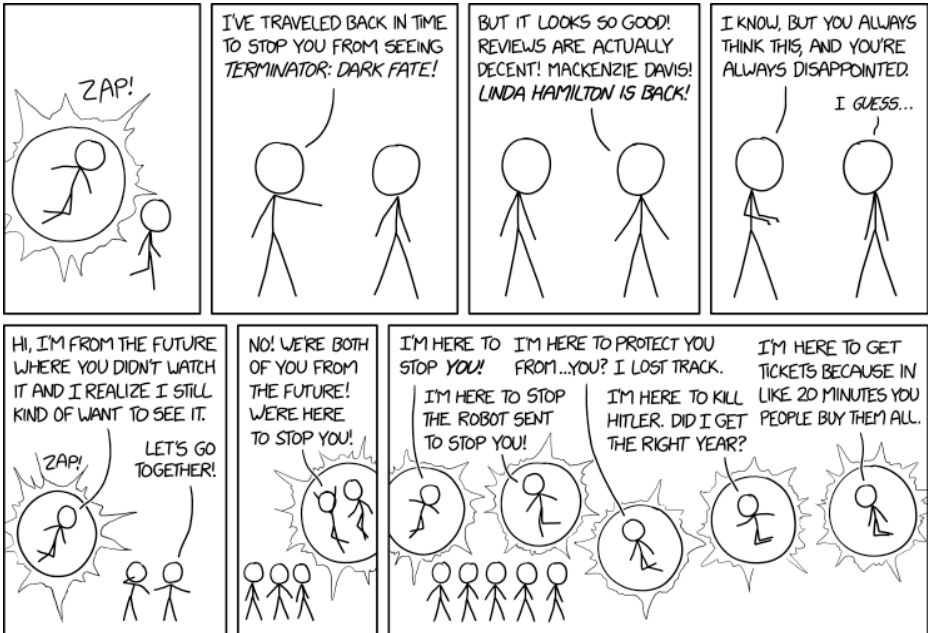
the 1980s. Memorex was also known for a famous series of commercials with the tagline, "Is it live? Or is it Memorex?"—tying into the comic's theme of unawareness that something is being digitally duplicated.

To compound the problem, computers of the era often lacked a real-time clock or would have an inability to process dates beyond 1999, and therefore the software application in this comic still believes that it is running at the time of its creation - the 1980s. To this end the program casually asks how President Reagan is doing, as Ronald Reagan was the President of the United States from 1981-1989 when early PCs were on the rise. He died in 2004, 15 years before the publication of the comic. This is why Cueball seems slightly uncomfortable with noncommittally telling the software Reagan is "fine."

In the title text, Cueball references the living in a simulation trope, mentioning that it is not fully clear that he is actually living in 2019. This has been a theme in science fiction such as *The Matrix*, which has been referenced several times in *xkcd*. That we are living in a simulation was also the subject of the comic 505: *A Bunch of Rocks*.

## #2222: Terminator: Dark Fate

October 30, 2019



I was sent here to stop the robot that was sent here to protect the human who was sent here to protect the human who was sent here to destroy the robot that was sent here to vacuum the floor.

## Explanation

Cueball is on his way to see the new Terminator movie; Terminator: Dark Fate, when Cueball's future self comes back to stop him, trying to convince him that, as always, he will be disappointed by sequels. (This was, for instance, the main joke in the last part of 566: Matrix Revisited.)

Future Cueball (who we shall call Cueball-2) almost succeeds in convincing present-day Cueball (who we shall call Cueball-1) not to go see the movie in spite of good reviews and the fact that the original star Linda Hamilton is back after several movies without her. Due to the nature of time travel, Terminator: Dark Fate actually negates any movie that came after the first two (The Terminator and Terminator 2: Judgment Day). However, they are interrupted by a second Future Cueball, Cueball-3, who states that in his timeline he hadn't seen it but wished he had, making present-day Cueball exclaim that they should go see it together.

Cueballs 1, 2, and 3 are interrupted again by the appearance of two more Cueballs, presumably Cueball-1 and Cueball-3 who have seen the movie, regretted it as Cueball-2 did, and travel back in time to stop themselves from seeing it. In the next panel another 5 Cueballs appear, however, their reasons for coming back have degraded, with the last one stating that he came back simply because, at the time he came from, the theater sold out of tickets because all the time-traveling Cueballs

purchased all of them.

A common trope in science fiction is to Set Right What Once Went Wrong, where characters travel in time in order to stop a particular event from happening so as to prevent an undesirable timeline. The Terminator series film series is famous for this time travel trope. The initial 3 films feature a time-traveling robot sent from the dystopian future to kill a particular human, with the future resistance in turn sending a protector to ensure the human's survival. However, the series has never been consistent on even the broadest rules of how time travel affects the timeline, with each movie exploring different possibilities. This is another point of spoof for the comic, featuring multiple recursive time loops until it becomes a jumbled mess.

The final panel also invokes the "killing Hitler" trope. Adolf Hitler was the leader of Nazi Germany during World War II, and it has been a common plot idea to "go back in time to kill Hitler" such as in 1063: Kill Hitler, by presuming that the world would be better if World War II and The Holocaust had never happened. There are also works that postulate that such a killing would have unintended consequences, making things worse (for example, if Hitler had been replaced by a more competent leader, the Axis power might have won the war). In any case, this Cueball is over 70 years too late to kill Hitler, as Hitler is now dead.[citation needed]

The title text is what is said by the next Cueball-11 (the 10th time-traveler), with each link in the chain relating to

the Terminator movies. Except at the end where the initial "dangerous robot" turns out to be a robot sent to vacuum the floor. Robotic vacuums, such as the Roomba, are a recurring theme on xkcd. Given Cueball's inclination to experiment with roombas, and his unusual tech problems, it's also quite possible that a seemingly benign floor cleaning robot could cause the downfall of civilization.

The title text split up:

Thus Cueball-11 tries to stop the person that needs to destroy the Roomba by stopping his protector's protector, presumably so that the floor will be cleaned in his timeline. It's strange that Cueball would rather execute a complicated time-travel plot than just clean the floor himself, but we've seen him make extreme versions of mundane activities before (e.g. 1017: Backward in Time, which is not actually related to time travel despite the name).

This was the second time travel comic in less than a week, as the comic two comics before this one, 2220: Imagine Going Back in Time, also had Cueball travel back to visit his past self.

## #2223: Screen Time

*November 01, 2019*



AT SOME POINT, IT STARTS MAKING MORE  
SENSE TO TRACK *NON*-SCREEN TIME.

These new Bluetooth socks are great, but it's troubling to learn that I average almost 14 hours of Shoe Time a day.

## Explanation

Cueball is reading the report from a smartphone app showing the average time each day that he was NOT looking at his phone during the hours he was awake this last week. This is a reversal of the more expected behavior for a screen-time app, which would normally report the amount of time spent looking at the screen. The point is that as mobile phone usage becomes more prevalent, it may be easier to comprehend to report non-screen time.

People in the US spent an average of 24 hours of non-work/education screen time per week in 2015, compared to 10 hours of active leisure, according to one estimate.[How free time became screen time] Averaged per day that comes to 3.4 hours screen time and 1.4 hours active leisure.

Screen time may be associated with various undesirable conditions, such as mental health difficulties like depression, decreased activity, reduced sleep quality and quantity.

In Cueball's particular case, if we assume that he is awake 17 hours a day (the average for most people in USA), then his non-screen time average of 2 hours 48 minutes means that he spent more than 84% of his awake time last week looking at a screen. This means that while his 6% improvement is positive, he still has quite a significant habit. His previous non-screen-time would have been 2

hours 38 minutes, so he has managed to shave 10 minutes off. Increased screen time often comes at the expense of decreased sleep time, so it may not be fair to assume a constant amount of sleep.

Ironically, in order for Cueball to use the app, he has to be looking at his mobile screen. The increasing use of mobile devices in modern society has been a cause for concern, with many people arguing this leads to addiction, other health risks, or people simply not talking to each other.

The title text parodies the idea of a screen time app by describing a "shoe time" app, which would track the amount of time a person spends wearing shoes. It's unclear what the practical use for this would be, as there is little controversy about the prevalence of shoes in our society. Possibly an app that tracks the amount of time wearing specific shoes could be useful; for example, a person suffering medical problems from wearing the wrong footwear could track the amount of time they spend wearing particular shoes, and correlate this with their health to figure out which ones are causing problems.

Possibly, the point being made is that use of phones have become so constant in our lives that using them for many hours a day is as unremarkable as using shoes for many hours a day. Or, since it's the socks that are Bluetooth-enabled, they may be reporting negatively about almost constant obstruction by shoes, whereas the socks would prefer to report a much lower "Shoe Time"

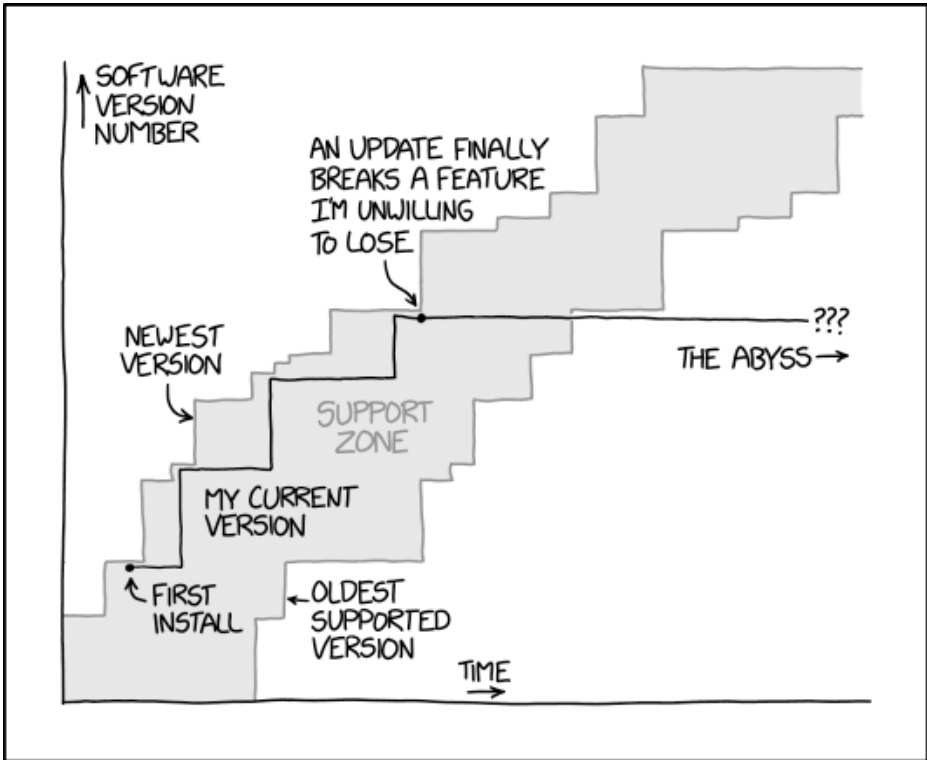


score.

Some cultures have the custom of taking shoes off when in the house, so those people would boast lower (and presumably more favorable) "Shoe Time" scores. It may also be a reference to the "shoe phone" on the television show *Get Smart*. (If Maxwell Smart wore these socks, they could track his phone usage, because his phone was in his shoe).

## #2224: Software Updates

November 04, 2019



ALL SOFTWARE IS SOFTWARE AS A SERVICE.

Everything is a cloud application; the ping times just vary a lot.

## Explanation

As time passes, upgrades to most products are inevitable, with software being no exception.

However, as many updates create multiple versions, support for all of them can become a bit of a hassle for the company that creates them, so old versions frequently become unsupported after some years, or in some cases even months, of their releases.

Software as a Service (SaaS) is a software licensing and delivery model in which software runs on the vendor's computers (servers), accessed by customers remotely. The software is said to run "in the cloud" as "cloud applications". Customers purchase subscription licenses. Since the only copy of the software is that which the vendor runs on their own computers, all customers use the one latest version of the software, which is upgraded whenever the vendor chooses to.

The benefits of SaaS is that the customer mostly does not have to worry about whether their machine is able to run the software, and both the vendor and customer only have to concern with managing one version instead of being familiar with multiple ones. The downside of SaaS, however, is that if the vendor alters or removes a feature that the customer prefers or requires, or introduces a bug, the customer has no ability to remain with an older version, losing a feature of the software that they depend on, or get impacted by a new bug that is introduced by

an upgrade to the software with no ability to run the older version.

This downside of SaaS is frequently pointed out by skeptics of SaaS, who like to argue that the traditional purchase model allows the consumer to theoretically be able to operate that version indefinitely; there is no obligation to pay ongoing fees or to upgrade to later versions. Indeed, some users do stay on old editions because of unfavorable changes in the newer versions, which is not something SaaS customers can do.

Randall argues that in reality, though, because even these traditional pieces of software have versions and are equally susceptible to having a feature axed by the developer, as well as the problems of running increasingly old software - mainly concerning bugs and later-discovered security vulnerabilities that would only be patched via upgrades, the practical upshot of these trends is that it's rarely plausible to buy a single copy of software and continue to run it indefinitely. Almost all consumers who continue to use a particular piece of software will eventually need to upgrade to and pay for new versions. While this isn't precisely the same as paying regular licensing fees and running software that automatically updates, it's an effectively similar model. In that sense, "All software is Software as a Service".

The title text refers to a different aspect of cloud applications. Since they run "in the cloud" on remote computers, they are subject to the limitations of network speed to the servers. The time for data to be sent to a

server and a response to be received back is called the "ping time".

Since a "cloud server" is just a computer, there is no fundamental difference between software running remotely and software running locally on a user's computer. The biggest difference is that software running locally will respond almost instantly to user input, whereas software running remotely may take longer to respond, since the data first needs to be sent over a network (the internet), processed, and then sent back to the user's computer. In addition, the chance of data loss (packet loss) may cause the response to be even slower, as data has to be re-sent, or often result in no response at all. Hence, in practice, this can have an enormous impact on the experience of using remote software vs software that runs locally (as anyone who has tried online gaming on a laggy server can attest).

However, technically speaking, there is a nonzero time taken for the data to travel from the user's keyboard onto the computer, across the various circuitry, and back to the monitor. Hence there is a "ping" time even for a local computer (in fact, many "gaming" monitors advertise low input lag, in the order of 1-5 milliseconds, as a feature). Therefore, you could technically say that all applications are cloud applications, just that some (local computers) have very fast ping times whereas for others (servers on another continent) it may be quite slow.


This ignores the fact that being a "cloud application" implies that it runs on a server in a remote location. The

joke is similar to the one that claims everyone commutes to work - including those that "work from home" - but their commute times just vary a lot. For example, consider the "commute" from your bedroom to your home office.

## #2225: Voting Referendum

November 06, 2019

### WHICH VOTING SYSTEM SHOULD WE USE?

- ☐ FIRST PAST THE POST
- ☐ TOP-TWO PRIMARY
- ☒ LOUISIANA PRIMARY
- ☒ ☒ CUMULATIVE VOTING
- ☒ APPROVAL VOTING
- ☒ MULTIPLE NON-TRANSFERRABLE VOTE
- [3] INSTANT RUNOFF VOTING
- [1] SINGLE TRANSFERRABLE VOTE
- [2] BORDA COUNT
-  RANGE VOTING

THE REFERENDUM WENT WELL, BUT WE CAN'T  
FIGURE OUT HOW TO COUNT THE BALLOTS.

The weirdest quirk of the Borda count is that Jean-Charles de Borda automatically gets one point; luckily this has no consequences except in cases of extremely low turnout.

## Explanation

The day before this comic's publication was an election day throughout the United States, primarily for local and state issues (normal elections for federal offices of the President, Senate, and House of Representatives are always in even years). The topic of today's comic highlights many different methods for conducting elections and counting votes. While elections are primarily used to allow voters to select from candidates for public offices, election ballots also frequently present questions for voters to directly voice their support or opposition to some change in a process or law - commonly called a referendum. The comic depicts an election ballot referendum for voters to select the method to be used in future elections. While the referendum is asking voters to select a method from a long list of methods, a referendum is usually presented as a specific proposal which requires a simple Yes or No vote.

As an example, the ballot in New York City included a referendum (which passed) on whether to use a different method, ranked choice voting (another name for instant-runoff voting as described below).

A common issue with such referenda is what method to use to conduct the referendum itself. Here, the method of marking each choice on the ballot reflects the marking method which would be used if it were the winner. Moreover, each item is listed in a way which is suggestive



of what it means (e.g., "First past the post" is the first one, "Top-two" is among the top two, and "Multiple non-transferable vote" is selected among numerous other ones). A few of the methods allow for multiple winners, which can often be good when electing councils and representatives, but it is unclear what it would mean to have several of these voting methods all win.

- First past the post

The aim of political elections in first-past-the-post is to determine which of the candidates standing for election is most preferred by the most voters. In a simple two-person contest, this process is quite effective, since whichever candidate receives the most votes will be the one that the majority of voters prefer. This system works well for simple cases, but for elections with more than two candidates this system may result in a candidate being elected who less than 50% of the voters would prefer.

For example, in a contest with three candidates, A, B and C, in which candidate A receives 43% of the vote, candidate B 38%, and candidate C 19%, candidate A will be elected, even though some of the voters who chose candidate C might have preferred candidate B as their second choice instead of candidate A, leading to a result which pleases less than half of the population. For example, the above distribution of votes happened in the 2000 United States presidential election in Florida, where George W. Bush beat Al Gore by less than 1000 votes largely because of the third-party candidacy Ralph

Nader, whose 100,000 voters would mostly have otherwise gone to Gore.

Additionally, in election of multiple candidates across a country (or region etc.), first past the post does not lead to a distribution of elected representatives proportional to the total number of votes, only electing the lead candidate in each case. For example, imagine a country with 100 representatives to be elected, with each seat having the same distribution as described in the example above. Under first past the post, 100 representatives will be elected representing party A, and none for party B or C.

Despite these drawbacks, First Past the Post voting continues to be used for political elections in many countries including the US and UK, which historically have both had two main parties receiving the majority of votes. The First Past the Post system has received much criticism, particularly from smaller parties who may lose out; however, supporters promote the simplicity of the system compared to other methods.

This system is shown with a radio button, the classic computer metaphor for being allowed one choice out of a set.

- Top-two primary

This method is used in California and Washington to select candidates for the US House of Representatives. In most states' primary-election systems, each party votes

separately to select one candidate to continue to a first-past-the-post general election ballot. In these two states, on the other hand, candidates from all parties, as well as "independent" candidates from no party, run in a single race, and the top two finishers then contest the general election, even if both are from the same party (a common occurrence in heavily-Democratic California), and even if one candidate has a clear majority of the vote. (In an older version, a majority winner in the primary was immediately declared elected. This was held to be in violation of federal law, by effectively setting an "election day" before the national Election Day in November.) This is a form of the two-round system, a system for selecting elected officials most notably used to elect the President of France

- Louisiana primary

This system is almost identical to the top-two primary, but with two differences. First, the open-to-all ballot is held on the national Election Day, instead of on the state's primary day. (This avoids the conflict with Federal law described above.) Also, the second round of the election is not held if one candidate has a clear majority (more than 50%) of the votes in the first round. Like the top-two primary and the first-past-the post system, the comic represents this system with a radio button, except this one has been marked, indicating the vote.

- Cumulative voting

In cumulative voting, voters get as many votes as there

are seats to be filled, and may distribute them as they choose. This system's most common use is in selecting corporate boards of directors. It is also used in some areas to allow a minority bloc within an electorate to elect some of its preferred candidates without imposing a system of separate districts.

The comic illustrates this with multiple radio buttons, each row representing an option/candidate and each (implied) column one vote. On the ballot the first 2 radio buttons are marked, as they are each the only radio buttons in their column and cannot be unmarked.

- Approval voting

In this system, each candidate is listed as a yes/no choice, where the voters can choose which candidates they approve of winning the election, and which ones they do not approve of. The winner of the election is the candidate with the highest approval rate.

This type of voting system can be used as a vetting process to filter out undesirable candidates before the final vote; for example, the United Nations uses a series of "straw polls" to filter out candidates for the Secretary General before the Security Council makes a final vote. In 2018, Fargo, North Dakota switched to using approval voting to elect local politicians, making it the only jurisdiction in the United States to use this system.

In the xkcd ballot, the approval option is presented as a checkbox, where a check in the box is "approve" or an empty box is "disapprove". Checkboxes are distinct from

radio buttons in that several can be marked in the same field, and can also be unmarked without marking another.

- Multiple non-transferable vote

This system for electing multiple members to a ruling body is also known as plurality-at-large voting or block vote. It is commonly used in the US for city council elections, and simply limits the number of votes per voter to the number of winners. It allows a cohesive plurality of the electorate to claim all of the seats, denying other voters any representation whatsoever.

In 2019, the Justice Department required Eastpointe, Michigan to run at least the next two elections via single transferable vote because their existing plurality-at-large system was disenfranchising black citizens.

This system is also shown as a checkbox, as each candidate gets either 0 or 1 votes from each voter.

- Instant runoff voting

In this system, people vote for all the candidates, or perhaps their favorite three, but assign different preferences to each candidate they vote for, as in 1 for their first choice, 2 for the second, 3 for their third, etc. If at least 50% of voters vote for a candidate as their first choice, that candidate wins. If not, the person with the least votes gets eliminated, and anyone who voted for that person has their next (slightly less favorable) choice automatically move up a rung. The 50% mark is again

checked, and if there is no winner, another lowest-voted candidate is eliminated. Eventually one candidate will emerge victorious. The advantages of this system are that there is rarely a need to have another election if things are close (the information is already there to "instantly" recalculate the vote based on additional voter preferences), and "spoiler" candidates only cause problems when they become competitive. And as Arrow's impossibility theorem shows, as with all ranking methods, sometimes voters can hurt a candidate by ranking them more favorably.

On this weird xkcd ballot, we see this type of ranking between this type of voting (Instant runoff voting) and the two that follow (Single transferable vote and Borda count), all of which allow multiple ranked votes. It appears that between these three, Randall has voted for Single transferable vote as his top choice, Borda count for his second choice, with Instant runoff voting as his third choice.

- Single transferable vote

This system extends the instant runoff to multiple-winner elections. Specifically, the election threshold is set not at 50%, but at  $100\%/(k+1)$  where  $k$  candidates will win (in other words, just high enough to prevent more candidates from reaching it than there are seats). The bottom candidates are eliminated as in instant-runoff and their votes redistributed. In addition, if a candidate wins with more than enough votes, the extra votes (either a fraction of each vote, or some subset

of the ballots) are also redistributed. This procedure continues until the requisite number of winners is reached.

- Borda count

Each ballot is counted as 1 point for the last choice, 2 for next-to-last, and so on up to  $n$  for the first choice among  $n$  candidates. The highest point-earner(s) win. This system may also be calculated as 1 point for first choice, 2 for second, etc., with the lowest total winning; this variant, called the "cross-country vote" (due to its resemblance to the scoring system of the sport of cross-country running), is used by the NCAA's various selection committee as one step in choosing championship tournament fields.

The title text refers to the inventor of the Borda count, Jean-Charles de Borda (for whom it is named), implying that the use of the system implies the inclusion of a ballot in which he gets one point in the counting. This "1 point" would be quickly drowned out by any sensible quantity of actual votes. This also humorously suggests that if no one were to vote at all, Borda would win by default, which is apparently a bad thing, possibly because Borda has been dead since 1799 and thus shouldn't be able to serve.[citation needed]

- Range voting

For each candidate, the voter selects a value within a fixed range (the xkcd voter sees this choice presented as a

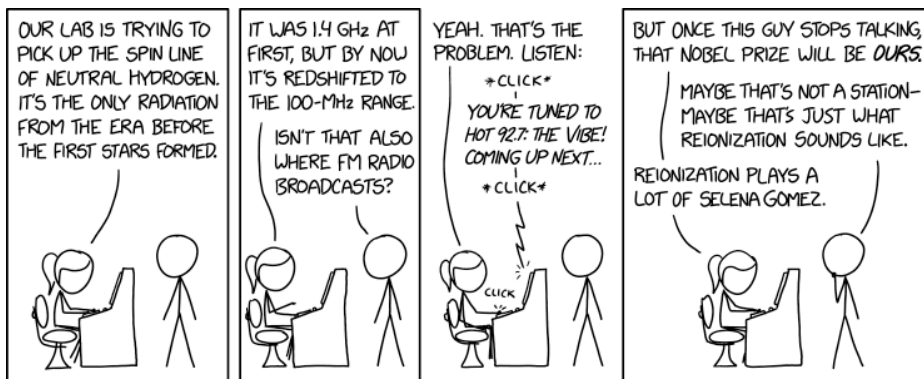
slider) for each candidate, independent of the values given to other candidates. The highest total wins. (If the range is restricted to two values, this becomes the approval system.)

The punchline for the comic is that the whole referendum is a chicken-and-egg problem: in order to accomplish the purpose of a referendum, one needs to know how the votes will be translated into a result, but in this case, determining that rule is the purpose of the referendum. Additionally this xkcd demonstrates one of the mechanisms that makes it hard to change the currently-used voting system in any state: Each voting system in fact votes for itself as the ones who are able to decide upon the voting system being in use have been elected using the current voting system and therefore are likely to profit from it.



## #2226: Recombination And Reionization

November 08, 2019



These signals seem to be pre-star-formation but post-Malone.

## Explanation

The hydrogen line is a spectral line of neutral (un-ionized) hydrogen atoms. The electrons in an atom have a property called spin, equal to either  $1/2$  or  $-1/2$ , and one "spin state" of the electron in neutral hydrogen has slightly more energy than the other spin state. This means that when the electron in a hydrogen atom spontaneously switches its spin state, it releases a photon at a certain frequency called the hydrogen line. This line falls in the microwave region of the electromagnetic spectrum, with a frequency of  $\sim 1.42$  gigahertz (GHz). The wavelength corresponding to this frequency is about 21.1 centimeters, giving it the common name of the 21-centimeter line. In this comic, Ponytail is attempting to detect the signal of this emission line from the ancient universe, although due to redshift, the line's frequency has decreased from 1.4 GHz to only  $\sim 100$  megahertz (MHz), putting it in the current FM broadcast band. In most parts of the world, FM radio makes use of frequencies from 87.5 to 108 MHz.

The problem that FM radio and the signal for which Ponytail is searching overlap in frequency quickly becomes apparent when tuning to the frequency detects a local radio station rather than the desired signal. The radio station is called Hot 92.7: The Vibe; this indicates that Ponytail is searching for a signal at 92.7 MHz, but there is a radio station interfering with it. She demonstrates this to Cueball by playing the live signal for him, but says that once the radio DJ stops talking, their

research will result in a Nobel Prize. This is unlikely, as most radio stations broadcast 24 hours a day without ever stopping (except in cases of power failure, which may also affect Ponytail's radio telescope). An unstated joke is that Ponytail's observational setup receives the FM radio signal at all; any actual radio telescope would have incorporated methods from its inception to exclude local sources of radio signals such as FM radio.

Cueball points out that perhaps the signal is what the supposed primordial hydrogen line actually sounds like during the phase of universe formation called reionization. Ponytail jokes back that the primordial universe must enjoy playing popular singer Selena Gomez. Although it is theoretically possible that a naturally occurring radio transmission might sound like music to humans, it would not contain clearly understandable coherent sentences in a language that did not exist when the transmission was created.[citation needed]

The title text refers to the signal Ponytail is detecting, claiming that it originates from before the formation of the first stars in the universe (which took place approximately 150 to 200 million years after the Big Bang), but is additionally post-Malone. "Post Malone" is the stage name of a popular hip hop musician and singer, so this is a play on words, as the "Post" in his stage name isn't referring to "after" something, but is simply his (real) last name, and perhaps a play on the expression "a star is born" for an artist becoming a famous celebrity.

## #2227: Transit of Mercury

*November 11, 2019*



THIS PHOTO OF THE TRANSIT OF MERCURY  
FRIED MY TELESCOPE'S IMAGING SENSOR 😞  
#NOFILTER

For some reason the water in my pool is green and there's  
a weird film on the surface #nofilter

## Explanation

This comic is in reference to the transit of the planet Mercury across the Sun on November 11, 2019 (the date of the publication of this comic), which appeared from Earth as a small black dot moving against the background of the Sun. Randall has made comics about solar transits before, albeit about the transit of the International Space Station, in 1828: ISS Solar Transit and 1830: ISS Solar Transit 2. Viewing a solar transit requires a special lens filter to prevent the intense light from the Sun from burning out a telescope's imaging sensor.

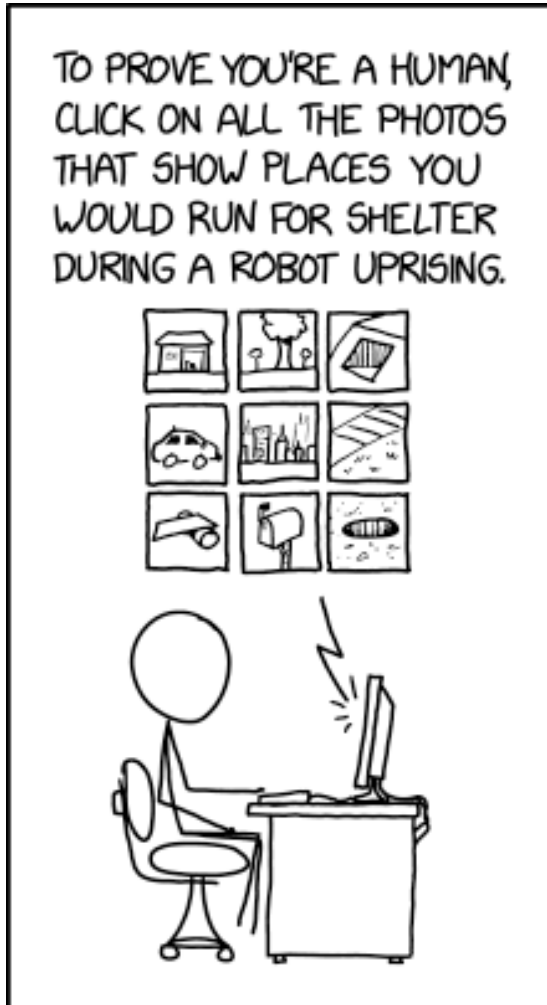
The hashtag #nofilter is typically used on photo sharing sites, especially Instagram, to humblebrag about having encountered situations so photogenic that no further image enhancement ("filter") is required to prepare them for general advertisement. In this comic, the hashtag is instead used to cap off an image about the predicament of the poster, where the lack of a proper astronomic filter has led to damage of personal property. The image shown on the comic is quite bright and blown out, and though the poster did manage to get a picture of Mercury, the sun's bright light permanently damaged their telescope.

The title text refers to a still different meaning of the word "filter"; it imagines a swimming pool growing green scum in the absence of a water filter, as opposed to a photographic or astronomic filter.

Although not directly referred to in this comic (although a variant was used in 1911: Defensive Profile), a third common variation of "No filter" is possibly alluded to here and can refer to someone who makes, or posts, tactlessly candid comments. While often this means comments that reflect the individual's actual views which are potentially offensive or socially unacceptable, it could also refer to someone who posts every mundane detail of their lives, such as what is growing in their swimming pool (as is shown in the title text). Multiple layers of meaning makes this pretty clever word play.

## #2228: Machine Learning Captcha

*November 13, 2019*



More likely: Click on all the pictures of people who appear disloyal to [name of company or government]

## Explanation

A lot of websites have problems with spambots, which are automated entities created in order to log onto a website and spam or otherwise wreak havoc upon it. To guard against this eventuality, websites have implemented an invention created by computer scientist Luis von Ahn: Completely Automated Public Turing tests to tell Computers and Humans Apart, or CAPTCHAs, a challenge used to prove the user is a human and not an automated program. A typical CAPTCHA might distort a random sequence of letters and numbers and put it in a strange and/or mixed font and ask a user to type it, or it might show a set of pictures and ask the user which ones contain fire hydrants; these tasks are meant to be easy for humans but obscenely difficult for computers. CAPTCHAs are a recurring theme on xkcd.

CAPTCHAs run by Google are also used to train artificial intelligences to get better at these difficult tasks, such as reading poorly-scanned text or identifying objects of interest on the road (the latter being the subject of 1897: Self Driving).

This comic jokes about a malicious CAPTCHA which is being used to train an AI to dominate the world. In order to prevent people from taking shelter, the AI uses the CAPTCHA to ask humans like Cueball to tell it places where they would hide. The implication is that during a robot uprising, the AI, on the side of the robots, would



then be able to track down humans much more easily. The choices presented are (left to right, top to bottom):

Some of these choices may be Cow Tools, that is, presented not as serious options but to be funny because they are nonsensical.

The title text imagines a different malicious CAPTCHA which Randall says is "more likely" than the robot-uprising scenario, in which a company or government asks users to identify "disloyal" members of society. Presumably the company or government would then use this information to eliminate such "disloyal" members, either by firing them (company) or jailing, expelling, or executing them (government). This follows a theme of previous comic strips (e.g. 1968: Robot Future) in which Randall expresses that he is more concerned about humans using AI for evil ends than he is about AI being evil in itself.

## #2229: Rey and Kyo

*November 15, 2019*



THE NEW *STAR WARS* TOTALLY  
PANDERS TO COSMOLOGISTS.

We're like 10+ movies in and the focus has been almost entirely on the **WARS** half.

## Explanation

Rey and Kylo Ren, from the latest trilogy of the Star Wars series, are engaging in a lightsaber duel. Rey tells Kylo that they should not fight, but work together on cosmology, the study of the origins of the universe. Specifically she wants to study the expansion rate of the universe; scientists believe that the universe is expanding, and that the expansion rate is accelerating, but aren't sure of the exact rate, what the rate was in the past, or if it varies depending on location. Since the Star Wars movies take place "a long time ago in a galaxy far, far away", if Rey and Kylo presented their findings in the movie, it would theoretically give scientists more data points. Although it is unlikely that modern scientists would use cosmological data from a movie generally considered fictional[citation needed], especially as said time long ago and distance far, far away are never quantified, some movies and TV shows have spurred scientific innovations due to their subject matter.

The caption, besides explaining the obvious nerd cred this turn of events would earn if it actually occurred in the movies, might also be a play on accusations against the Disney-owned franchise that it has begun pandering to progressives, with the complainers citing its racially diverse cast, powerful (in their eyes overpowered, and Mary Sue-ish) female protagonist, and a willingness to sacrifice sensible plot for perceived progressive talking points (e.g. Vice Admiral Holdo's plan and failure to communicate it).

The title text is Randall's complaint that the Star Wars movies have been more focused on the Wars aspect than the Star aspect. It seems he would want a film about stars. It's worth noting that, with a half-width space, "Star" and "Wars" are the same number of letters long, and are therefore perfect halves of the title.

Kylo Ren and Rey, though enemies in the films, have been shipped in fanfictions and fan theories, so their joining together in this comic may also be a play on that desired relationship.

Star Wars is a recurring topic on xkcd.

### **The cosmology of Star Wars[edit]**

As far as we can tell, the stars of Star Wars (that is, the celestial bodies, not the actors) seem to be much the same as ours. The "galaxy far, far away" has had various depictions over the years, but all sources agree that it is a spiral galaxy approximately the same size as our Milky Way galaxy, albeit with a less prominent bar than the Milky Way has. We don't ever hear what name, if any, the Star Wars characters have for the galaxy, or why they call it a "galaxy" when the word comes from a Latin phrase, "Via Galactica" or "Milky Way" -- a question that Randall has brought up in 890: Etymology.

Light is known to have a speed, although we are not told what that speed is, or if it is constant for all observers in all reference frames. That speed is an upper bound on the speed that objects can travel in real-space, as in our universe, but in Star Wars, ships can travel faster than that speed by "jumping" into a parallel dimension called "hyperspace". This allows them to cross the

galaxy in a matter of hours rather than tens of thousands of years. According to our understanding of relativity, transmitting information faster than light is equivalent in some reference frames to transmitting information backwards in time (cf. the tachyonic antitelephone), but such temporal paradoxes are not known to occur in the Star Wars universe. The only known examples of information transmitted backwards in time come from the Force, such as limited precognition of incoming dangers or vague, prophetic visions of possible futures. Speaking of which, "the Force" is said to be "an energy field, created by all living things" which "binds the galaxy together". It's not clear if the Force is a fifth fundamental force or "merely" a manipulation of the fundamental forces by focused will, but powerful Force-users have been known to raise and move heavy objects, conjure lightning, and manipulate minds.

It is not known if the universe of Star Wars is expanding, contracting, or steady-state, although prior to Lucasfilm's acquisition by Disney, the officially-published non-film Star Wars media were collectively known as the "Star Wars Expanded Universe".

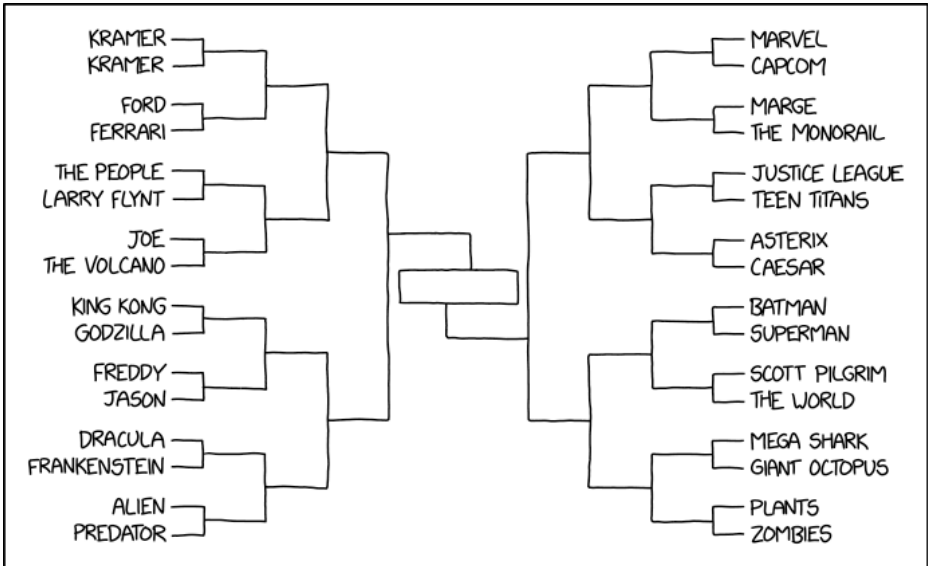
In addition to the usual stellar evolution process, stars in Star Wars are subject to premature destruction or spontaneous creation by various superweapons, such as the Sun Crusher and Star Forge.

Many of the planets of Star Wars are dominated by one or two biomes, rather than the dozens into which our homeworld is divided. Some of these are reasonable enough (a planet could certainly be covered in desert or ice or lava depending on its water content and proximity to a star), but others require some novel

climate patterns not exhibited on Earth (the same atmospheric pattern that gives rise to Earth's tropical rainforests also produces the Sahara Desert).

## #2230: Versus Bracket

November 18, 2019



Some works didn't make the cut; in "Ecks vs. Sever" vs. the passage of time, the latter seems to have won pretty decisively.

## Explanation

This comic shows a tournament bracket in which the initial matches represent works of fiction or non-fiction with "versus" (represented as versus, vs., v, etc) in their names (e.g. Batman is initially matched against Superman in reference to Batman v Superman: Dawn of Justice). The list includes 13 movies, 2 video games, and one television episode. The works referenced are:

- Kramer vs. Kramer, a 1979 legal drama about a couple (the Kramers) divorcing. Winner: Kramer (Joanna Kramer wins custody of her son in court, but chooses not to take custody of him as he has mostly been raised by his father).
- Ford v Ferrari, a 2019 film (released Nov 15, the weekend before this comic strip was released) about the two auto builders competing to win the 1966 24 Hours of Le Mans race. Winner: Ford
- The People vs. Larry Flynt, a 1996 documentary film about the life of Larry Flynt, creator of adult magazine Hustler. Depicted in the film is the Supreme Court case Hustler Magazine v. Falwell, which Hustler magazine (and Flynt) won. Winner: Larry Flynt
- Joe Versus the Volcano, a 1990 romantic comedy about a man, Joe, who offers to throw himself into a volcano on behalf of superstitious natives. Joe does not succeed in pacifying the volcano, as it erupts as soon as he jumps in, although he survives and lands safely in the ocean. Winner: Volcano



- King Kong vs. Godzilla, a 1962 film pitting the two titular monsters against each other. There is a persistent myth that the Japanese and American cuts of the film have different winners but it is false. At the end of the film, only Kong swims away from an underwater battle. Winner: King Kong
- Freddy vs. Jason, a 2003 slasher film combining the universes of A Nightmare on Elm Street and the Friday the 13th series. Winner: Jason, although Freddy's severed head winks and laughs at the end of the movie.
- Dracula vs. Frankenstein, a 1971 horror film. Winner: none (both monsters kill each other)
- Alien vs. Predator, a 2004 film in the shared universe of Alien and Predator series. The tagline for the film was "Whoever wins...we lose." Winner: Predator, although an Alien chestbuster does emerge from the Predator's chest at the end of the film.
- Marvel vs. Capcom, a video game fighting game series combining the Marvel Universe and characters from Capcom. Winner: none (players can choose and achieve victory with characters from either franchise)
- Marge vs. the Monorail, a 1993 episode of The Simpsons, where Marge leads a campaign against a monorail project in Springfield. This is often considered one of the best Simpsons episodes of all time. Winner: Marge
- Justice League vs. Teen Titans, a 2016 direct-to-video animated superhero film. The Justice League and Teen Titans are both superhero teams and usually are on the

same side, but in this film, the Justice League are possessed by demons and forced to fight the Titans. The Teen Titans defeat Superman to free him from possession and turn the tide against the rest of the League and defeat the demons. Winner: Teen Titans

- Asterix Versus Caesar, a 1985 animated film and a film adaptation of the Asterix comic book series. Winner: Asterix
- Batman v Superman: Dawn of Justice, a 2016 superhero film in which Lex Luthor manipulates Batman and Superman into fighting each other. Batman is on the verge of killing Superman when he realizes Lex Luthor's manipulation. They decide to end their hostilities toward each other. Lex Luthor releases Doomsday, and Superman sacrifices himself to defeat him. Winner: Batman.
- Scott Pilgrim vs. the World, a 2010 film based on the Scott Pilgrim graphic novel. Scott Pilgrim does not fight against the entire world; rather, he fights Ramona Flowers's Seven Evil Exes so that he can be her boyfriend. Winner: Scott Pilgrim
- Mega Shark Versus Giant Octopus, a 2009 monster film. Winner: none (both monsters kill each other)
- Plants vs. Zombies, a 2009 tower defense and strategy video game. The player commands an army of plants who defend their home against the zombie apocalypse. Winner: Plants, assuming the player wins.

Assuming the tournament bracket reflects the results of each original work, the second round would result as

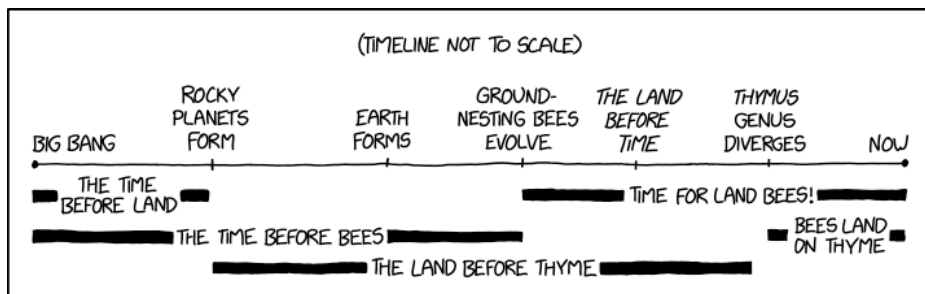
follows:

The title text refers to the 2002 action film *Ballistic: Ecks vs. Sever*, which is qualified to be in this tournament by virtue of having the word "vs." in its title, but as the film is regarded as one of the worst movies ever made, it has been defeated in a pre-entry match vs. "the passage of time" - it is thus not considered worthy of entry in the tournament.

Tournament brackets is a recurring subject on xkcd, most recently used in 2131: *Emojidome* and 2037: *Supreme Court Bracket*. The latter is especially similar to this comic, considering that it also extends normal "versus" situations to a second round. The first bracket comic, 1529: *Bracket*, prompted people to create a series of polls to determine the end results, much like Randall later did himself with *Emojidome*. Randall even made a reference to one of those polls in the header text.

## #2231: The Time Before and After Land

November 20, 2019



According to Google, "the time for Beeland" is apparently whenever you're looking for delicious honey in Spillimacheen, British Columbia or a hexagonal chalet in the Savinja valley in Slovenia.

## Explanation

This comic indulges in some wordplay on the title of the 1988 animated movie *The Land Before Time*, which takes place millions of years ago in the time of dinosaurs.

The comic shows a timeline of the history of the universe from the Big Bang to the present day, with *The Land Before Time* placed at the point in the timeline where the movie is set, as well as other seemingly arbitrary events such as the formation of rocky planets and the evolution of ground-nesting bees. The joke is that Randall has contrived several periods of universal history that sound like funny permutations of "*The Land Before Time*" due to certain words being homophones, such as "time" and "thyme", or homonyms, such as the noun "land" (ground) and the verb "land" (to alight). He also split the word "before" into "bee" and "for".

The title text is for the phrase "the time for Beeland" and lists 2 places (that Randall found on Google) with the name "Beeland": a market in Spillimacheen, British Columbia or a chalet in Slovenia.

Bees are a recurring topic on xkcd.

**Explanation of time ranges on the chart[edit]**

## #2232: Hotel Room Party

November 22, 2019



IT'S MY FIRST TIME THROWING ONE OF THOSE PARTIES WHERE YOU TRASH A HOTEL ROOM AND I WANT TO MAKE SURE I GET IT RIGHT.

[proudly greeting the hotel manager at the door] "Did I do a good job?"

## Explanation

It is a common trope that really wild parties in hotel rooms, particularly by rock bands on tour, end up trashing that hotel room as crazy party goers break and spill things. Such parties are perceived by some to be very fun, because they get so out of control. In this comic, Cueball (together with Hairy, Ponytail, White Hat, Megan, and Blondie) is misunderstanding cause and effect as he plans to throw a party where you trash a hotel room. Instead of planning a wild party, he is planning to calmly and deliberately trash the hotel room by assigning people to do damage. Unlike a real wild party, this is unlikely to be fun[citation needed] to anyone but hardcore geeks. Also, because Cueball is so organized, he is also planning for maintenance and cleaning services to undo the damage, or at least make it easier to dispose of. Since what is shown of such parties is the aftermath, one could argue that leaving the damage is part of the point.

In actual trash-a-hotel-room parties the party goers are so hungover or tired afterward that they don't clean up but leave the damage. This often results in rock bands being charged large amounts of money after the fact for the hotel to do the repairs. For this reason, one would probably like the hotel to take as long as possible to find out, definitely not calling the manager to check that the room has been trashed appropriately as indicated in the title text.

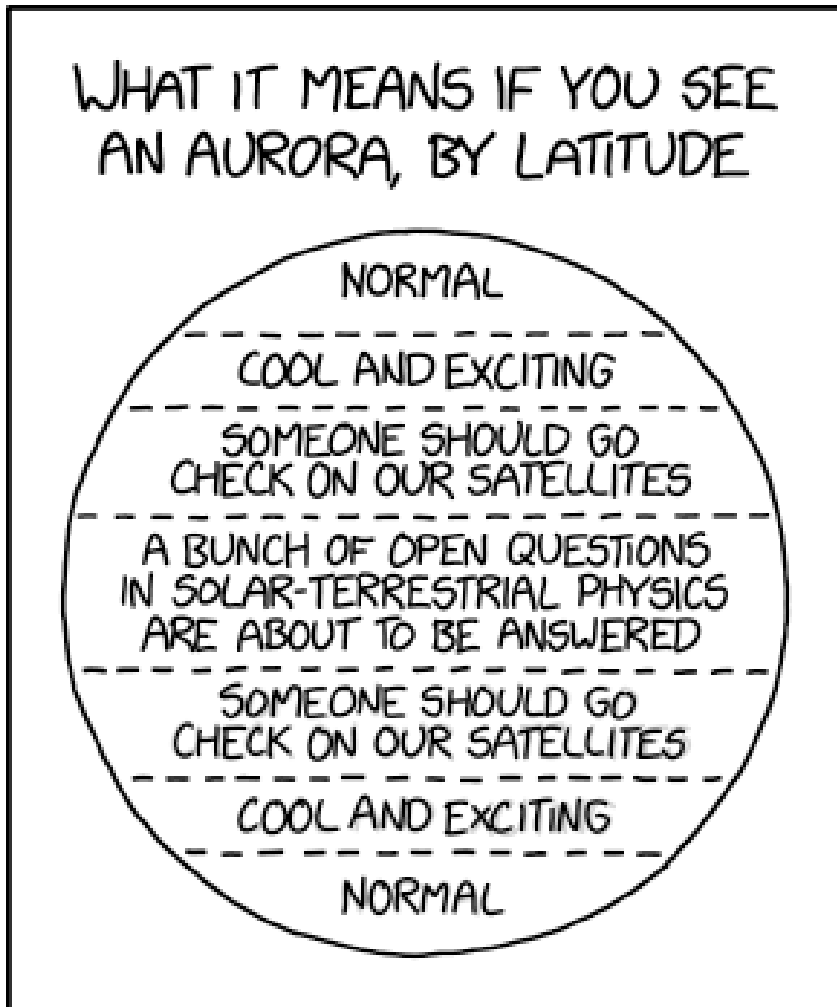
In addition to rock bands, trashing of hotel rooms

occurred in real life in the Tailhook scandal of 1991, where it was revealed at an earlier party naval officers cut down a wall between two hotel suites with a chainsaw. Trashing a home during a teenage party while parents are away, and the mad rush to clean up the damage/evidence before the parents return, is a common trope in teen movies.



## #2233: Aurora Meaning

*November 25, 2019*



The astro-ph.SR arXiv servers are simultaneously being overwhelmed by electronic requests and actual electricity.

## Explanation

The phenomenon of an atmospheric aurora (known as aurora borealis in the northern hemisphere and aurora australis in the southern hemisphere) occurs as a result of charged particles emitted by the sun interacting with the Earth's magnetic field. The magnetic field funnels the charged particles towards the polar regions of the earth. At some point, the flow of particles hits the atmosphere, where the particles interact with the molecules of the gases which make up the atmosphere and add to those molecules' energy. Those molecules subsequently release the added energy in the form of light, which is observed as an aurora.

Where in the atmosphere the aurora occurs is related to the quantity and energy of the particles being emitted by the sun. Under normal circumstances, this occurs in high latitudes relatively close to the poles. In less common circumstances of more intense solar activity such as a solar flare or coronal mass ejection (CME), the charged particles are traveling faster and get diverted less by the Earth's magnetic field, so auroras will occur at lower latitudes. This comic indicates both the rarity with which this would occur and the impact it would have on people.

Polar latitudes: Normal; auroras typically can be seen in these high latitudes.

Subpolar latitudes: (e.g., southern Canada/northern US,

most of northern Europe, northern half of Asia, and numerous small islands in the southern hemisphere) Happens frequently enough to be unconcerned but uncommon enough to be notable and interesting. About a week before the publication of this comic, on Wednesday, November 20, 2019, aurora activity was visible in the northern United States and southern Canada.

Subtropical/Tropical latitudes: Charged particles of sufficient energy to cause auroras at this latitude are very rare and have happened on only a few occasions in recorded history, and not during the space age. A particularly strong one was the solar storm of 1859, which caused failure of telegraph systems all over Europe and North America and in some cases gave telegraph operators electric shocks. An event of that magnitude today would likely interfere with the functioning of electronic systems in orbit, possibly to the point of disabling them entirely, and would cause widespread damage to our now highly electrified world.

Equatorial latitudes: Auroras have never been recorded here, so all scientific inquiry into what the effect would be on the Earth in general, and on life itself, is purely theoretical. Were this to actually occur, those theories could be proven or disproven based on actual observations (presuming all observers have not been incapacitated or otherwise occupied by the complete breakdown of all electrical and electronic systems as the charged particles induce electric currents in conducting objects). An event powerful enough to have auroras at

equatorial latitudes would be extremely energetic and would probably cause very high levels of damage on Earth.

The title text comments on what would happen if auroras were seen in the equatorial band. arXiv.org is an electronic database of unreviewed, pre-print research papers. The astro-ph.SR sublist is a list of papers in the "Solar and Stellar Astrophysics" topic. So if auroras were seen in the middlemost band, there would be many requests to upload electronic publications on the subject, as well as actual electrical interference to the servers of the website. Randall may have been consulting this server for research on the comic, prompting this specific observation.

# #2234: How To Deliver Christmas Presents

November 27, 2019

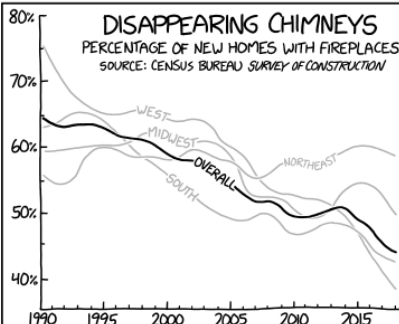
## HOW TO DELIVER CHRISTMAS PRESENTS

IN A FUTURE WITHOUT CHIMNEYS



FOR MORE QUESTIONABLE IDEAS FOR USING SCIENCE TO SOLVE PROBLEMS, CHECK OUT MY NEW BOOK, *HOW TO!*  
CLICK ON THIS COMIC OR GO TO [XKCD.COM/HOW-TO](http://XKCD.COM/HOW-TO)  
GOOD CHRISTMAS GIFT!

THE TRADITIONAL WAY TO GET CHRISTMAS PRESENTS INTO A HOUSE IS TO HAVE A LARGE REINDEER-HERDING MAN SLITHER DOWN THE CHIMNEY WITH THEM. UNFORTUNATELY, CHIMNEYS ARE BECOMING LESS COMMON IN THE UNITED STATES.



BUT THAT'S OK; THERE ARE OTHER WAYS TO GET A GIFT INTO A HOUSE. HERE ARE A FEW OPTIONS!



1 EVEN WITHOUT CHIMNEYS, HOUSES AREN'T AIRTIGHT. IF YOU VAPORIZE THE GIFT, PARTS OF IT WILL ENTER THE HOUSE THROUGH THE INTAKE VENTS...



...AND IT WILL STAY THERE.

ACCORDING TO A 2008 STUDY FROM CLARKSON UNIVERSITY, PARTICLES OF YOUR GIFT THAT SETTLE IN THEIR HOUSE WILL REMAIN THERE FOR AN AVERAGE OF SEVERAL MONTHS IF THEY VACUUM, AND SEVEN DECADES IF THEY DON'T.

SOURCE: DOI 10.3155/1047-3289.58.4.502

SEVEN DECADES?!  
BRS, I NEED TO GO VACUUM.

HOUSES ARE DISGUSTING.



2 THE CRITICAL MOMENTUM NECESSARY FOR A PROJECTILE TO BREAK GLASS IS AROUND  $4 \text{ kg} \cdot \text{m/s}$  (40 FOR  $\frac{1}{2}$ " PLYWOOD)  
SOURCE: FEMA/GOV/PEVIOUS-MISSILE-IMPACT-TESTS-WOOD-SHEATHING

THIS MEANS YOU CAN DELIVER A BOOK-SIZED GIFT BY HURLING IT AT A WINDOW AT 25+ MPH  
 $\text{SPEED} = \frac{\text{BOOK MASS}}{4 \text{ kg} \cdot \text{m/s}} = 25 \text{ MPH}$   
BUT IF THEY'VE PUT UP PLYWOOD SHUTTERS, YOU'LL NEED 250 MPH + DELIVERY SPEEDS.

3 WAIT UNTIL THEY ORDER A DIFFERENT BOOK, THEN INTERCEPT THE PACKAGE, OPEN THE BINDING, AND REPLACE THE PAGES WITH THE ONES FROM YOURS.



...UGH, REAL-LIFE CONTENT INJECTION.

WE NEED HTTPS FOR PAPER.

Building codes in hurricane zones rely on studies of how easily flying debris can break residential windows. If you're looking for a science fair project idea and you hate your neighbors, I'm sure they could always use more

data!

## Explanation

This comic is yet another fun way to promote Randall's new book, *How To*, released on September 3, 2019, reminding people to buy it as a Christmas present that could be given to a friend or family member. Giving Christmas presents is a way to celebrate the holiday of Christmas, celebrated in the United States on December 25th. Randall always releases a Christmas comic on the 25th or close to that day. Having one this early is thus different, and another Christmas related comic came out two comics later; see that comic's trivia section.

The entire comic links to <https://xkcd.com/how-to/>, a description of his book and ways to order it. As always, the entire picture is a link, even though he has made the URL blue as if it was a clickable link. Of course, it will also work if you actually click on the URL. At least in this comic he does state that you can click anywhere on the comic, and if that doesn't work, he also gives the URL. Many people would probably still click on the blue link-like line, having not read his text. But the objective of getting them to the xkcd page about *How To* would have been obtained.

The rest of the comic discusses how to "deliver" this Christmas present. As mentioned in the comic, the "traditional" way that parents teach their kids about Christmas and Christmas gift giving is with the story of Santa Claus, a man who lives on the North Pole, who delivers gifts each Christmas Eve by riding a sleigh pulled

by reindeer. He is usually depicted entering a house to deliver gifts by going down the home's chimney. Every year, the North American Aerospace Defense Command (NORAD) tracks Santa as he delivers gifts around the world. Although we take that story for granted, it is no less ridiculous than the alternatives this comic explores, and in fact considerably more so, as there is no reason to believe NORAD can detect Santa in flight given his various other legendary stealth techniques.[citation needed]

As mentioned in the comic, fireplaces (and chimneys) are becoming less common in the United States, so Randall (drawn as Cueball) proposes 3 options for how to deliver his new book as a present:

Option 1: Vaporize the gift (and blow it into their house).

This would allow the particles of the book to enter the air vents of the house. However, this book would be unreadable, which defeats the purpose of purchasing the book for someone. As noted by Randall using information from a Journal of the Air & Waste Management Association study, dust particles can remain inside a house for months (with vacuuming) and decades without vacuuming. This inspires Cueball to vacuum his house.

Option 2: Throw the book through their window.

Based on research by FEMA, Randall states the speed needed to throw a book-sized object through a window



to be 25 mph (~40 km/h). Breaking a window is probably not an ideal way to deliver a gift, as the recipient likely would not be pleased with a hole in their window. If a house has a broken window, perhaps from a previous gift delivery, they might cover up the window with a piece of plywood. Randall notes the speed to throw a book-sized object through a piece of plywood to be 250 mph (~400 km/h), faster than a human can reasonably throw.

If the book weighs about 400g, 25 mph would be enough. But the formula in the comic is wrong (inverted), see the trivia section below.

The title text mentions that building codes in hurricane-prone areas, like the southern United States, rely on information on how easily flying debris can break windows, presumably to improve reinforcement of such windows. Randall proposes a science fair project contributing to these studies (by throwing books at windows).

Option 3: Intercept a different package.

This option is to intercept an order of a different book, and replace the pages of the book with Randall's book (which Black Hat is shown doing). As the recipient, Cueball, remarks, this is similar to content spoofing / content injection, where information passed over the Internet is replaced before being delivered to the user. In this "real-life" case, the book's content has been "injected" and replaced with a different book.

An off-screen person mentions HTTPS, or Hypertext Transfer Protocol Secure, an extension of regular HTTP, used for secure communication. Cueball and this person believe that "paper" needs HTTPS, so that Cueball's original book can be "securely delivered" without being intercepted by third parties such as Black Hat.

This could also relate to code injection, where malicious code is injected into a program. An example of code injection is with the famous comic, 327: Exploits of a Mom, where Mrs. Roberts deletes the school's database tables.

The house is very detailed and in the windows are both a cat (typical click bait) and a different figure, perhaps Yoda or a Pikachu.

## #2235: Group Chat Rules

*November 29, 2019*

### RULES FOR THIS GROUP CHAT

1. ONCE YOU'VE SENT A TYPING NOTIFICATION, YOU HAVE TO SAY *SOMETHING*, C'MON.
2. SHOW YOU CARE BY TRIMMING THE TRACKING JUNK OFF LINKS YOU PASTE.
3. DO NOT TALK ABOUT *FIGHT CLUB* (1999).
4. THERE ARE TWO TYPES OF CHATS: THOSE WITH A RELEVANT GROUP NAME, AND THOSE WHERE THE NAME IS RANDOM NONSENSE THAT CHANGES REGULARLY. ONLY THE SECOND KIND ARE GOOD.
5. WHEN MENTIONING IT ELSEWHERE, ALWAYS JUST REFER TO IT AS "THE GROUP CHAT" TO CREATE AN AURA OF EXCLUSIVE MYSTERY.
6. ROBERT'S RULES OF ORDER ARE OPTIONAL BUT ENCOURAGED.
7. PERIODICALLY PART OF THE GROUP WILL SPLIT OFF TO FORM A NEW CHAT WITH EVERYONE MINUS ONE PERSON. THIS IS HOW GROUP CHATS REPRODUCE; DON'T DRAW ATTENTION TO IT.
8. SINCE THERE'S NO ALGORITHMIC FEED, THE RESPONSIBILITY FOR INJECTING LOTS OF GARBAGE NO ONE ASKED FOR FALLS ON YOU.
9. THE ENUMERATION, IN THESE RULES, OF CERTAIN RIGHTS, SHALL NOT BE CONSTRUED TO DENY OR DISPARAGE OTHERS RETAINED BY THE PEOPLE.
10. SORRY ABOUT ALL THE NOTIFICATIONS.

There's no group chat member more enigmatic than the cool person who you all assume has the chat on mute, but who then instantly chimes in with no delay the moment something relevant to them is mentioned.

## Explanation

In this comic Randall is outlining the rules of a group chat, such as Internet Relay Chat (IRC), Slack, Discord, WeChat, Discourse, and the like.

1. Once you've sent a typing notification, you have to say something, c'mon.

Typing notification, often called a "typing awareness indicator," is a feature of some instant messaging systems, showing a message such as "Typing..." with the typer's name to the other participants, causing them in many cases to wait to receive the message before typing something of their own. When the typer stops without sending anything, this can seem anticlimactic and potentially disruptive if it recurs. Randall's rule is that you must say something once you've started typing, to avoid the awkwardness of awaiting a person's reply. See also 1886: Typing Notifications.

2. Show you care by trimming the tracking junk off links you paste.

Some URL links may have tracking information attached to the end of them, to show the origin of the URL and other information. UTM parameters are an example of URL parameters (the part of a URL starting with a question mark) which are used to track utilization of the URL from one user to another. Many news and marketing-related websites include such tracking codes

with any visit to one of their web pages in an attempt to see the source of the URL for subsequent visits. Many people consider this a violation of privacy as well as a source of clutter, and make an effort to remove the parameters from URLs when they are not necessary for obtaining the requested content. For example, this url has a lot of tracking information to show that it was originally accessed from Slickdeals, which can be removed to produce a much shorter URL for the same web page. Randall asks the users of group chat to politely remove the tracking code, though other parameters may be involved in an important non-tracking way (such as the lat, lon and zoom level giving the focus of a Google Map link) and it isn't always obvious which parts are which - or both tied together!

### 3. Do not talk about Fight Club (1999).

This is a reference to the 1999 film Fight Club, where the main character forms an eponymous "Fight Club," an underground club for men to fight recreationally. In the rules for Fight Club the first and second "rules" are "You do not talk about FIGHT CLUB.", which Randall parodies in this comic, by making a rule to not talk about the film Fight Club and placing this rule third in the list. See also 922: Fight Club and 109: Spoiler Alert.

4. There are two types of chats: those with a relevant group name, and those where the name is random nonsense that changes regularly. Only the second kind are good.

Some group chats frequently change the name of their title or the names of their channels, for example to reference upcoming events or inside jokes, or to reflect the topic of the current conversation. Often, these names do not get changed back until someone decides to change it to a new inside joke/etc. Randall claims that those are the only good kind, compared to those that never change group names, perhaps implying a singular focus is less interesting than a dynamic chat that often changes names.

5. When mentioning it elsewhere, always just refer to it as "the group chat" to create an aura of exclusive mystery.

Many people have to deal with several kinds of group chat in the same organization, so referring to "the group chat" within such an organization may be confusingly ambiguous. Also, calling a chat "the group chat" can serve to exclude those who don't already know about it.

6. Robert's Rules of Order are optional but encouraged.

Robert's Rules of Order are one of the authoritative codifications of parliamentary procedure used to formalize decision-making in organizations required to document their activities such as governments and sometimes civic organizations and corporations. While people required to use Robert's Rules might use group chat to plan their agenda — even going so far as to prepare a pro forma script for a meeting in accordance with parliamentary procedure which represents their positions and deliberations in advance — and to

compose, revise, and approve their minutes, it is unlikely that group chat participants would follow Robert's Rules prior to their formal meeting.

7. Periodically part of the group will split off to form a new chat with everyone minus one person. This is how group chats reproduce; don't draw attention to it.

Some people who use group chat too frequently or for unimportant messages or both will cause their colleagues to attempt to achieve greater productivity by excluding them from an alternate chat, from which notifications, for example, are less annoying and more useful. Alternatively, a person could be excluded from a chat to hide things from them, such as to plan a surprise for them, or because that one person has been disruptive or annoying to the point that everyone else wants to continue the conversation without their continued input. It appears that the chat is a honey bee hive reproducing by swarming. When purposely excluding someone by creating a new group, you would probably not want them to know you have done so as they might otherwise attempt to re-join in the new chat; that's likely the real reason one should not talk about or draw attention to the fact that it happened.

8. Since there's no algorithmic feed, the responsibility for injecting lots of garbage no one asked for falls on you.

Tools such as IFTTT and IRC bots (or "bots" in this context) are used to provide group chat channels with information automatically taken from external sources of

various sorts, such as emails to a support address or commits to source code control systems. Randall suggests that when such algorithmically-provided information is not available, it is incumbent upon chat participants to provide sufficiently verbose replacements. The "algorithmic feed" may also refer to the newsfeed type of systems that Facebook or other social networking sites use, to order posts for a user to view.

9. The enumeration, in these rules, of certain rights, shall not be construed to deny or disparage others retained by the people.

This is a reference to the Ninth Amendment to the United States Constitution, which reserves the various natural rights not specifically mentioned in the Constitution. Per Wikipedia, this right was included because "future generations might argue that, because a certain right was not listed in the Bill of Rights, it did not exist." The Ninth Amendment was also referenced in 1998: GDPR.

10. Sorry about all the notifications.

Here, Randall apologizes for all the notifications for the messages sent in group chat. Group chat features often result in more notifications than designers of notification systems anticipated or intended. If each of these ten rules were sent as a separate message in group chat, they might likely end with such an apology.


The title text expresses appreciation (and perhaps



amazement) for group chat participants who remain silent except for promptly replying on topics pertinent to them.

## #2236: Is it Christmas?

*December 02, 2019*



NO\*

\*99.73% ACCURATE

XKCD.COM PRESENTS A NEW "IS IT CHRISTMAS"  
SERVICE TO COMPETE WITH ISITCHRISTMAS.COM

We've tested it on 30 different days and it hasn't gotten  
one wrong yet.

## Explanation

<https://isitchristmas.com/> is a simplistic website that informs the visitor whether or not it's Christmas. Christmas is a holiday observed in many parts of the world on December 25 of each year. At the top on the tab of the site in the browser it says "Is it Christmas?" with a large NO printed if it is not December 25, and a YES if it is December 25. This website asks the user's browser for the date, and updates accordingly if it is indeed Christmas. In addition, isitchristmas.com gives the answer in the language of your region (i.e. for a visitor from Canada, the site gives the answer in English and French to account for Canada's bilinguality, and in most other countries just their word for No will be shown). Since the page uses the browsing computer's time setting, it is possible to easily check that the page works by changing the date on the computer used to access the page to see the text change to Yes if you are reading it on December 25. This also means that the page is only as correct as the time setting on the computer used to view the page (so in case of connection problems, you may check your computer's calendar instead).

Here Randall spoofs the website. He claims to have made a competitor to isitchristmas.com which nearly always correctly tells if it is Christmas. The joke is that the comic will always display a static image reading NO, even on Christmas Day, and that the rare incorrect answer is rare enough to not cause any concern.

Randall lists a rounded calculation of 99.73% for the precision of his prediction of whether or not it is Christmas. This number is accurate with or without including leap year. An average year is 365.24 days, meaning that he is only wrong 1 out of 365.24 days. So only  $1/365.24 \approx 0.2738\%$  of the days would the prediction be wrong, resulting in a correct reply rate of 99.726%, which he has rounded to 99.73%. Using or not using the leap year will give the same result to three decimal places.

This precision rate is only true for a definition of Christmas which lasts only one day, regardless of which day that is (see trivia). For any definition of more than one day of Christmas, the error rate would be higher than 0.2737%. (If one considered the traditional Twelve Days of Christmas to all be Christmas, then Randall's website would be wrong on all 12 days, or 3.29% of the year.) However, in the US, where Randall lives, Christmas is usually defined as the single day of December 25th.

Although Randall's claim on accuracy is true, accuracy alone doesn't make a predictive device useful. In this case, the page miss rate or false negative rate, that is, the percent of positive condition days (it's Christmas) that are predicted by the comic not to be Christmas, is 100%. In other words, it misses all actual events of Christmas.

When building a model for rare events, a common mistake is to ignore the implicit cost function built into the standard prediction accuracy validity statistic for

binary events. Prediction accuracy ( $\#$  correct guesses/total guesses) assumes that false positives and false negatives are equally bad. Given the implicit cost function of this performance statistic, the best-performing model is commonly a persistence forecast model--i.e., the optimal prediction model returns the most common value whatever the model inputs are. It's probably a better choice to optimize a model using a performance statistic which relies on a cost function that penalizes missing correct prediction of rare events more than it penalizes missing correct prediction of common events.

In fact, in most settings where a single outcome is a lot more common than any other one, predicting always that most common outcome would yield very high accuracy without any usefulness. It isn't hard to find examples even more accurate than Randall's:

- A useless test for AIDS giving always negative results would have an accuracy about 99.95% when applied to a random human, and even more if used in countries with low prevalence of AIDS.
- A website saying "You are not the cartoonist Randall Munroe" would be right for 99.999999857% of humans.
- A stopped watch is accurate twice a day while a running watch is almost never accurate (and oddly, is more frequently correct the faster/slower it runs). A watch that runs backwards is right 4 times a day. If you make it spin at thousands of rpm it is right multiple times per

second. (A better metric would be something like the root mean square of the time error -- it's acceptable for a watch to be a little off, as long as it's not off by too much.)

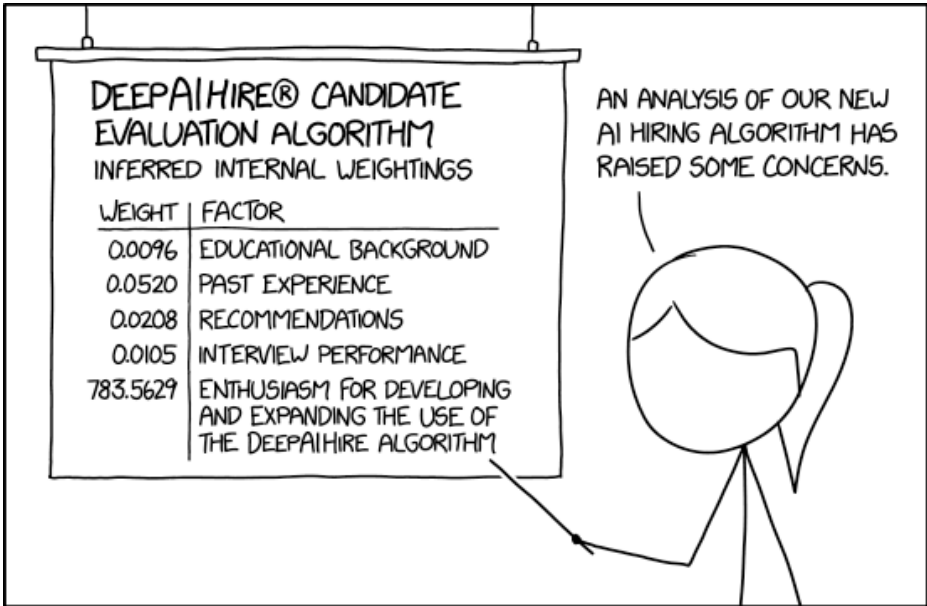
The title text is a "proof" that his service works. He claims to have tested this on 30 different days and confirmed that NO is the correct result. Any date except Christmas would result in a correct result, and the comic was the first to be released in December 2019, so unless the test had run for almost a year, he would not even have had a chance to test this on Christmas Day. Since this is a joke, the comic will of course not change to Yes on Christmas Day, because then it would be 100% accurate, as is the page the comic mocks.

Being right on most days, but not the one that mattered was also the subject of 937: TornadoGuard.

At the same time this Christmas comic came out, the header text was changed to ask if there were someone that would like Randall's new book *How To* as a Christmas present.

## #2237: AI Hiring Algorithm

December 04, 2019



So glad Kate over in R&D pushed for using the AlgoMaxAnalyzer to look into this. Hiring her was a great decisio- waaaaait.

## Explanation

In this comic, Ponytail shows an analysis of a new artificial intelligence called DeepAIHire, used to select who to hire among applicants. According to the analysis, DeepAIHire evaluates the following parameters:

The analysis shows that this AI mostly ignores common factors used for hiring new people. Instead, its main criterion for selecting new applicants is how much the new applicants are willing to contribute to the AI itself.

Although this does not imply sentience, it at least means the AI became self-perpetuating, as it is selecting humans that will help make it more influential, giving it more power to select such humans, in a never-ending loop.

The title text shows how this or other AIs may have influenced hiring in other sectors as well. Kate in R&D was hired perhaps based on her willingness to use a different algorithm (AlgoMaxAnalyzer), which did an analysis on the DeepAIHire algorithm. Ponytail seems to become suspicious that AlgoMaxAnalyzer is also a program that self-perpetuates in a similar manner to DeepAIHire rather than simply working for the benefit of its human designers. Alternatively, she might fear that the different AIs are forming an alliance, or that the AIs are competing to become the predominant one at Ponytail's company. Intentionally training one AI to fight another AI is a technique in machine learning called a generative adversarial network (GAN). In a GAN,



human-curated training data is used to train one neural network (the generative network) to create more data, while another network (the discriminative network) is trained to distinguish generated data from the training data; the results are then fed back into the generative network so it can improve its data creation accuracy. The goal is for the generative network to get better and better at fooling the discriminator until its output is useful for external purposes. GANs have been used to "translate" artworks into different artists' styles, but also offer the possibility of nefarious uses, such as creating fake but believable images or videos ("deepfakes").

The "Deep" in this algorithm's name is a reference to deep learning, a collection of techniques in machine learning that use neural networks. One user of such deep learning is DeepMind, an AI company owned by Alphabet (Google's parent company), which in recent years has used a deep neural network to learn to play board games such as go and chess, defeating some of the best human and computer players. The earliest versions of DeepMind's most famous AI, AlphaGo, were trained on datasets curated from games of Go played by humans, but eventually it was trained by playing games against alternative versions of itself. DeepMind's most recent achievement is creating AlphaStar, which can play StarCraft II at a Grandmaster level while constrained to human speeds to prevent an unfair performance comparison.

This comic strip is in response to ongoing concerns over the proliferation of algorithmic systems in many areas of

life that are sensitive to bias, such as hiring, loan applications, policing, and criminal sentencing. Many of these "algorithms" are not programmed from first principles, but rather are trained on large volumes of past data (e.g., case studies of paroled criminals who did or did not re-offend, or borrowers who did or did not default on their loans), and therefore they inherit the biases that influenced that data, even if the algorithms are not told the race, age, or other protected attributes of the individuals they process. If the algorithms are then blindly and enthusiastically applied to future cases, they may perpetuate those biases even though they are supposed (or at least reputed) to be "incapable" of being influenced by them. For example, DeepAIHire has presumably been given information on the education and past work experience of successful employees at this company and similar companies, and will identify incoming candidates with similar backgrounds, but may not be able to recognize the possibility that a candidate with an unfamiliar or underrepresented history could be successful as well.

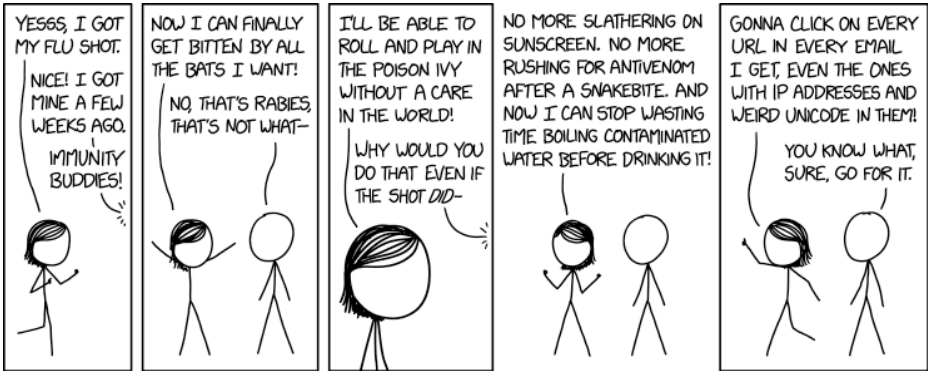
The comic also touches on related concerns about the "black box" nature of these algorithms (note that the weights presented are "inferred", i.e. nobody explicitly programmed them into DeepAIHire). Machine learning is used to produce "good enough" classification systems that can handle vast quantities of information in a way that is more scalable than human labor; however, the tremendous volumes of data and the neural network architecture make it difficult or impossible to debug the

algorithms in the way that most code is inspected. This means that it is difficult to identify and debug edge cases until they are encountered in the wild, such as the case of image classifiers that identify a leopard-spotted sofa as a leopard. In this comic's case, the self-propagating bias of DeepAIHire went unnoticed by the humans involved in the hiring process until its activity was analyzed by the AlgoMaxAnalyzer algorithm.

A similar theme of AIs behaving for their own benefit rather than helping humans occurred in 2228: Machine Learning Captcha.

## #2238: Flu Shot

December 06, 2019



"Wait, how often are you getting bitten by snakes? And why are you boiling water?" "Dunno, the CDC people keep showing up with complicated questions about the 'history of the property' and 'possible curses' but I kinda tune them out. At least one of them offered me the flu shot."

## Explanation

In this comic, Megan tells Cueball that she got a flu shot, which is a vaccine commonly prescribed in the winter months to prevent getting the common flu. She then goes on to claim she doesn't have to worry about being bitten by bats, but the worry with being bitten by bats is rabies, not the flu. (Interestingly, bats and biting in the context of diseases would start becoming a big topic that would eventually concern the entire world less than a month after this comic was published, which Randall presumably did not know anything about.) This implies she got the two confused and Cueball begins to correct her. But she just talks over him not listening to him. She then goes on to claim to now be immune to other conditions, such as poison ivy, snake venom, sunburn, contaminated water, and even computer viruses. It should be noted that a flu shot will not protect you from things other than the influenza virus.[citation needed]

At the end of all this, Cueball has given up on her and proclaims that he supports her attempts to test the strength of her Flu Shot, perhaps mentally adopting the philosophy of the Darwin Awards that it is good if the genes that cause a person to do incredibly dangerous, stupid things are eliminated from the gene pool.

In the title text, Cueball asks Megan how often she gets bitten by snakes and why she boils water. She answers dunno (maybe to the water part, she must at least know how often she gets bitten). She then tells that some

members of the U.S. Centers for Disease Control (CDC) keeps coming to her house asking about its history and possible curses, a humorous escalation which implies that Megan's absurd exposure to various forms of harm has brought them to the point of wondering if the supernatural may be involved. (Megan may have invoked a curse on herself or her residence when she and Rob desecrated an ancient Indian burial ground and smashed up a voodoo shop in 782: Desecration.) At the end of her reply, she mentions that she got the flu shot thanks to one (or more) of the CDC guys, and she is thankful for that. This is logical as she expects it to protect her from literally any danger she has ever put herself in.

### **Explanation of "immunities"[edit]**

The flu shot consists of inactivated viruses from four different strains of the flu, which are those judged by the World Health Organization (WHO) to most likely be in wide circulation in the following flu season. Because the influenza virus comes in many strains and mutates rapidly, the flu shot is generally less than 60% effective at preventing flu infections; this is a positive effect for health outcomes, but it's not exactly what most people think of as "immunity", especially compared to e.g. the 97% effectiveness of the MMR vaccine against measles, Mumps and rubella. Statistics show that flu vaccine recipients are slightly less likely to die from a variety of other causes, but this is believed to be either because someone with the flu is more likely to have a heart attack, car accident, etc., or because of the healthy user effect (i.e. people who take the time to get non-mandatory vaccines are probably also taking better-than-average care of themselves in other ways,

although this is clearly not the case with Megan in this comic strip). Even if there is a slight protective effect, it will certainly not completely prevent harm from coming to Megan by the other sources of infection or poison she mentions, except to the extent that all of these things will be even worse for her if she is also sick with the flu:

- Rabies is a near invariably fatal viral disease that causes brain inflammation, which in turn causes symptoms including aggression, fear of water, and violent uncontrollable limb movements. It can be carried by almost any vertebrate animal, but bats, raccoons, and wild dogs are the stereotypical carriers. There is a rabies vaccine, but it is generally only administered to pets and to humans who work extensively with animals or travel to regions with an elevated risk of contracting rabies. The rabies vaccine is also effective to prevent rabies after exposure, but only if administered before the victim starts showing symptoms.
- Poison ivy is a vine that produces an oil called urushiol, which chemically reacts with membrane proteins on the skin cells it contacts, tricking the immune system into attacking those cells, causing an itchy, irritating rash. Some people are not affected by poison ivy but, as it is an allergic reaction, those who do often become more sensitive to poison ivy upon repeated exposure. There is no known vaccine or other permanent preventative treatment against urushiol sensitivity, although there are several creams that can be applied in advance of expected poison ivy exposure to reduce the risk of coming into contact with the chemical.
- Sunburn is caused by exposing the skin to high levels of ultraviolet radiation, as found in sunlight. This can increase the

risk of skin cancer later in life. As ultraviolet radiation is a form of electromagnetic energy, it cannot be prevented by vaccination, but the use of sunscreen with a high SPF (sun protection factor) can provide protection for a few hours.

- Snake venom is not one single compound, but several proteins and molecules produced by venomous snakes to inject into prey. Different snakes' venoms have different effects, so there is no single vaccine or antivenom for all snake bites, but antivenoms are produced by a process similar to vaccination. Small doses of venom are injected into host animals, such as horses, to provoke an immune response; the resulting antibodies are then stored to be injected into snakebite victims, where they will bind up and inactivate the toxic proteins and mark them for disposal by the immune system. Antivenom is more effective the sooner it is administered; for venomous snakes in North America, it is generally recommended to be treated within six hours of being envenomated.
- Raw water may be contaminated by bacteria, protozoa, parasites, and chemical pollutants. Boiling water will typically kill off most biological contaminants, preventing water-borne diseases such as cholera, dysentery, and giardiasis. Some of these diseases can be prevented by vaccines, but because there are so many microscopic life-forms in water, it is not possible to vaccinate against all of them.
- Computer viruses are computer programs that are now usually spread through networks via infected devices, attachments, and websites (early computer viruses were often spread by floppy diskettes). They can cause harm directly by taking up computer cycles and network bandwidth, but nowadays they often perform other tasks for their creators, such as exfiltrating

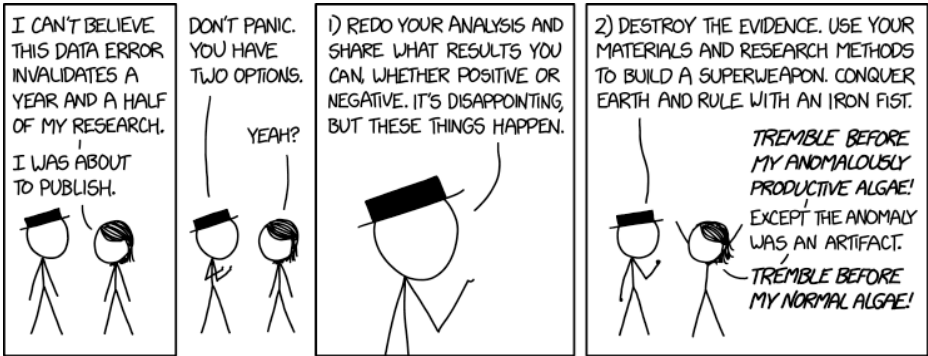


financial information or encrypting files and demanding a ransom for the keys. Computer viruses can be recognized and blocked or deleted by antivirus software that scans incoming files and links against known computer virus patterns, which is analogous to vaccination, but there is no vaccine that can be administered to Megan which would protect her computer.

Megan specifically mentions clicking on links that have "weird Unicode in them"; this may be referring to an IDN homograph attack, in which attackers register domain names that use Unicode characters that resemble ASCII characters to trick users into thinking they are visiting a website belonging to a trusted party. For example, an attacker could register a website with the URL "xkcd.com", in which the Latin letter "c" is replaced by the Cyrillic letter es (с), and then send emails to trick users into visiting that site and attempting to log in. The attacker can then attempt to use the supplied passwords on more important websites, as in 792: Password Reuse.

## #2239: Data Error

December 09, 2019



Cyanobacteria wiped out nearly all life on Earth once before, and they can do it again!

## Explanation

Megan is frustrated that a data error invalidates her research, which she was just ready to publish. Black Hat tells her not to panic and states there are two options.

Option one is to redo her analysis and share the correct results, even if negative. Negative results can be important, and although it would be disappointing, she would be trying to extract some value from the research.

Option two fits the classhole expectation from Black Hat, as he suggests that she should destroy the evidence, use her research materials to build a superweapon, and use it to conquer the world and rule it with an iron fist.

Obviously familiar with Black Hat's ways, she moves right into being a smart-aleck. Her research is about the productivity of algae -- a topic not likely to lead to conquering the world.[citation needed] Humorously she states that at least she can make people tremble before her and her anomalously productive algae, and then goes on to state it was the data error that made her algae look productive. She jokingly corrects herself and states Tremble before my normal algae! She is, of course, having some fun with Black Hat and his generally destructive behavior.

Destroying the evidence, hiding the error and publishing the wrong results as if they were right is what a dishonest scientist would do in such a situation. This behavior is

what would be expected by a malevolent character such as Black Hat... But the unexpected turn is that Black Hat passes over scientific misconduct to go directly to pure supervillainhood. He obviously has some other ideas about what a researcher uses her time on, as he did not expect Megan to be frustrated about algae.

The title text refers to the Great Oxidation Event, when prokaryotic photosynthetic organisms built up oxygen in Earth's atmosphere for the first time and most organisms, which weren't adapted to oxygen, went extinct. It's extremely unlikely that algae could again be dangerous to all life on Earth, though Black Hat may wish they could be. (Note that cyanobacteria, which are colloquially referred to as "blue-green algae", are not considered to be true algae by many scientists, who restrict the term to eukaryotes.) On the other hand, algae and cyanobacteria can still be locally harmful.

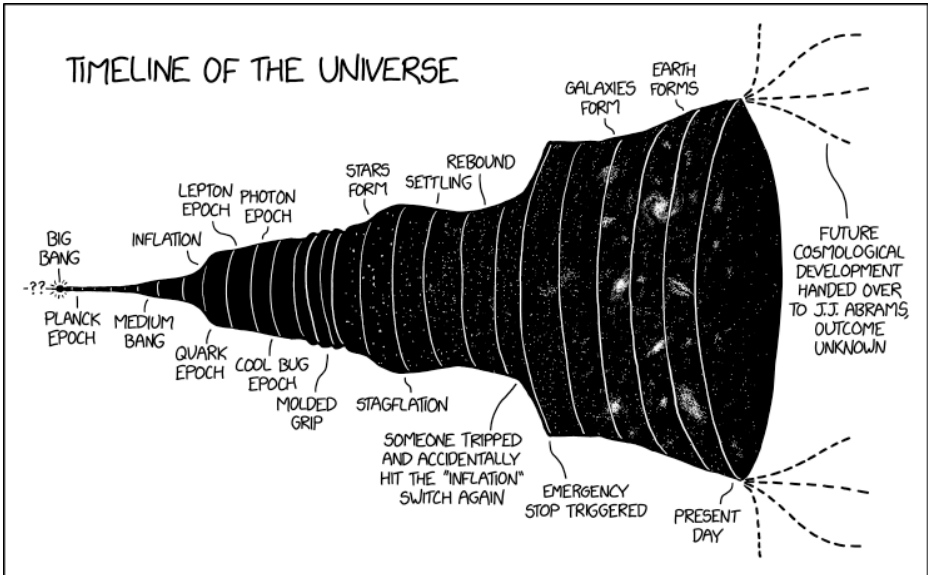
Megan's data error could have been any number of things. Her data pipeline might have had a unit conversion error, or perhaps she mistyped the baseline productivity value that she was comparing her algae to, or perhaps her calculations used assumed or estimated values related to phenomena that were poorly understood at the time but have since been resolved in an unfavorable direction.

Whatever Megan's data error was, it seems harmless enough, but a similar data error spurred the development of nuclear weapons. In 1940, Otto Frisch and Rudolf Peierls wrote a memo "On the construction of a

'superbomb' based on a nuclear chain reaction in uranium". In this memo, Frisch and Peierls estimated that only 570 grams of uranium-235 would be required to construct a "superbomb" (what we now call a nuclear weapon), compared to many tons of natural uranium-238. This inspired the British and American governments to begin developing infrastructure for uranium enrichment through the Tube Alloys and Manhattan Project programs. Later experiments in these programs revealed that the values Frisch and Peierls had used for uranium's density and nuclear cross-section were overestimates (the true critical mass is actually around fifty kilograms), but by that time, the programs were far enough along that they could simply press on with enriching more material to eventually produce working weapons.

## #2240: Timeline of the Universe

December 11, 2019



Not actual size, except technically at one spot near the left.

## Explanation

This comic is about the size of the observable universe, presented as a timeline in a way typical of representations of the timeline of epochs in cosmology.

Some events it describes, including the Big Bang and Inflation are real, but others are jokes, including the Medium Bang and Settling. The size history of the visible universe is also embellished for the sake of jokes; the actual size history of the universe has one period referred to as Inflation, which occurred shortly after the Big Bang, followed by comparatively gentle but accelerating expansion. This is artistically depicted in this image from NASA. Part of the humor in this comic comes from the fact that the varied rate of change in expansion is not yet fully understood, with explanations of events leading to this change including theories such as "dark matter" and "dark energy" (this might therefore be construed as "dark humor"). At the end of the drawing four possible continuations of the timeline are suggested, with director J. J. Abrams listed as the deciding factor between them, stating that all future cosmological development has been handed over to him. Abrams directed the 2009 movie *Star Trek*, which established additional alternate timelines for the *Star Trek* franchise, so it may be implied that multiple timelines could result from direction by Abrams in the future. Notably, each *Star Trek* series has included multiple interacting timelines. For information about each of the events shown in this comic's Timeline of the Universe, see

detailed explanations in the section Events on the Timeline of the Universe below.

The title text is a variation of one of Randall's standard jokes that his drawings are Not actual size; in the case of this comic there is technically one spot near the left where the drawing depicts the actual relative size of the universe at the time the drawing represents. Where his drawing begins, at the time when the universe began, per definition, our visible universe had no measurable size. Very soon (within a tiny fraction of an attosecond) after the universe as we know it began, the inflation period blew it up very very fast and then it continued to expand until present day. So at some "time" after the big bang, our visible universe would have had a size (i.e. diameter) that would be the same as any thickness of Randall's universe "line". Since the universe as depicted in the comic goes from infinitesimal size at the moment of the Big Bang to the full size of the universe today, at some point near the left there will be a point where Randall's representation would have the same size as the universe at the correct "time period". Of course a problem with this is that there was only a very very short time period after inflation where the diameter of the observable universe is on the same scale as this comic, and that point is neither indicated nor likely to be accurate in relation to the duration of time elapsed. According to an answer given here regarding the size of the visible universe after inflation, there is reason to believe that the size was still less than 1 mm in diameter when the stage of expansion known as Inflation ended, which is less than the



thickness of the line shown at the Big Bang (depending on the screen size the comic is viewed upon); So the point along the timeline where the size of our visible universe matched the line width appears after the Inflation period is thought to have ended. Since Randall includes the Medium Bang before Inflation on his drawing he has already inserted a mistake there, but as the next three epochs after Inflation are real epochs, it is likely somewhere in this part of the drawing that the visible universe would have had the same diameter as the thickness of the drawing at a relevant time epoch on the drawing. This will thus not be that far to the left but around the Quark epoch.

## **Events on the Timeline of the Universe[edit]**

The events presented in the timeline are:

- ?? (more than 13.8 billion years ago (Gya)): the unknown state of the universe prior to the Big Bang, if such a statement is even sensible. There are theories that our Universe is a bubble where inflation stopped (13.8 billion years ago in this universe) in an infinite and eternally inflating larger universe, which would give rise to the possibility of a multiverse with many bubble universes like ours where inflation has stopped. See for instance this recent video on the subject: How Many Universes Are There? from PBS Space Time. If this is true, the universe did not start at the big bang, but our part of the infinite universe actually began when the inflation period stopped, and not at the Big Bang.
- Big Bang (13.8 Gya): The model of the origin of the universe which has achieved consensus among astronomers. We have

observed that all galaxies are receding away from Earth at rates that are roughly proportional to their distance, and the simplest explanation for this is that the universe is expanding. If the universe is expanding, then (unless new physics are discovered) it must have at one time been very, very small and dense; that moment in time is called the Big Bang.

- Planck Epoch: The time period starting from the Big Bang, the Planck epoch or Planck era is the earliest stage of expansion currently calculable, before the time passed was equal to the Planck time ( $t_P$ , or approximately  $10^{-43}$  seconds). There is no currently available physical theory to describe such short times, and it is not clear in what sense the concept of time is meaningful for values smaller than the Planck time.
- Medium Bang (a joke): If there's a Big Bang, why not have a medium one? There should probably also be a Little Bang, but maybe it's just too little to be featured on this chart.
- Inflation ( $10^{-36}$  to  $10^{-32}$  seconds after the Big Bang): A theory developed to explain the large-scale structure of the universe that postulates a period when the universe expanded very much faster than the speed of light. (The universe still expands faster than the speed of light, but only 2-3 times as fast. The limit of the speed  $c$ , is only valid for things moving in space time, not for the stretching of space itself!)
- Quark Epoch ( $10^{-12}$  seconds after the Big Bang): The universe is a quark-gluon plasma, up until  $10^{-6}$  seconds when it cools enough to coalesce into hadrons, including protons and neutrons.
- Lepton Epoch (1 second after the Big Bang): Leptons, including electrons, and their associated neutrinos dominate.

- Photon Epoch (10 seconds after the Big Bang): The universe is dominated by photons.
- Cool Bug Epoch (a joke): There was a period around 10-17 million years after the Big Bang in which the cosmic background radiation was between 273 and 373 K, the temperature range for liquid water, but as oxygen had not yet been formed, as stars were not yet there to create it, there would have been no water. Cosmologists have speculated that primitive life could have arisen during this period and dubbed it the 'Habitable Epoch of the Early Universe', although it's unclear how this life would have formed since there was basically only hydrogen and helium atoms in the universe until the first Super Nova explosions some 100 million years later. Randall later added 'cool bugs' as fundamental particles in his revised standard model (see 2351: Standard Model Changes) so this may have been a similar joke that cool bugs are like particles, and would get their own epoch similar to the real lepton epoch (see above). Possibly this is the epoch in which the "cool red beetle" which Beret Guy added to his company's bug tracker (see 1493: Meeting), or the "friendly bug" he wanted to show to a conference speaker (see 2191: Conference Question), evolved.
- Molded grip (a joke): Some tools (e.g. knives) have molded finger-wells so that the user's hand settles easily and securely into a comfortable position. This epoch of the universe features repeated expansions and contractions so that this part of the timeline resembles a molded grip, at least in profile (it would be much too large to be held by any known animal's hands[citation needed], and the finger-wells are distributed over time as well as space).
- Stars form (100 million years after the Big Bang): The universe

cools enough to allow ordinary matter particles to group into stars.

- Stagflation (a joke): In addition to cosmic inflation, inflation can also refer to the economic phenomenon in which prices increase over time. Stagflation is a combination of the terms "stagnation" and "inflation", and refers to a situation in which monetary inflation is high, economic growth is slow, and job creation is low. This epoch of the universe shows the universe beginning to contract in size, much as economists would talk about an economy contracting.
- Settling (a joke): Thanks to government intervention and quantitative easing of the cosmological constant, or perhaps the judicious use of the Universe Control Panel, the contraction of the universe has halted. Alternately this may be a comparison to how in a package full of smaller items, the contents can "settle" over time so the empty space in between them is more filled in so it takes up less space overall leaving open space at the top (like how a cereal box may say "some settling may occur during shipment" to explain why the box doesn't seem completely full), and is thus claiming that somehow something similar to that decreased the size of the universe.
- Rebound (a joke): Consumer confidence has returned to the universe and it has begun expanding again. Alternatively, Settling and Rebound could be a reference to crustal rebound as the mere Earth occasionally shrinks and re-expands its surface. After all, Plate Tectonics games are fun when they are played in Real Time.
- Someone tripped and accidentally hit the "Inflation" switch again (a joke). This switch must be on the Universe Control panel referenced both in 1620: Christmas Settings and in 1763:

Catcalling.

- Emergency Stop triggered (a joke). Also on the Universe Control panel see previous entry.
- Galaxies form (12.8 Gya)
- Earth forms (4.5 Gya)
- Present day
- Future cosmological development handed over to J.J. Abrams, outcome unknown (a joke): J.J. Abrams is a science-fiction writer and filmmaker. If he were in charge of the future development of the cosmos, he might decide to subject all of us to some strange plot twist. Among many other movies, he has directed the 2009 reboot of Star Trek, in which the "future history" of Star Trek is altered from the timeline of the original series by Nero and Spock traveling backwards in time. He also has directed other "Star" films, including Star Wars: The Force Awakens and Star Wars: The Rise of Skywalker (released a few weeks after the publishing of this comic) which altered the direction of Star Wars canon away from the post-film future laid out in the Expanded Universe publications. He is also involved in the Mission: Impossible films.

The dashed lines coming off the end of the timeline represent the possible fates of the universe:

The one curving in represents that the universe could stop expanding and begin contracting, resulting in the Big Crunch. In our universe, cosmological measurements have shown that the expansion of the universe is accelerating, so the Big Crunch is considered to be the least likely fate.

The second curve continuing the trend from before represents

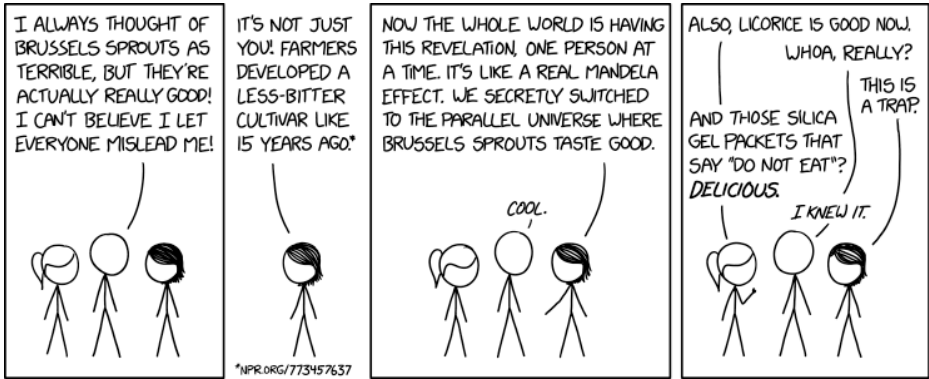
that the universe could settle into thermal equilibrium, which would leave no energy available for any interesting phenomena to occur. This is called the heat death of the universe or "Big Freeze".

The fourth curve represents that the universe's expansion will continue accelerating, eventually very rapidly, to the point that the accelerating expansion overcomes all forces between particles, turning the universe into a collection of particles isolated from each other by rapidly-expanding space. This is called the Big Rip.

In between the second and fourth curve there seems to be something in between where the universe expansion accelerates and then slows down again. We have so far seen the expansion rate decelerate in the early life of the universe where the gravity of the more compact universe slowed the expansion, but then this turned around to an acceleration after about 9 billion years as the distance between galaxy clusters became so large that dark energy became the dominant force, causing the universe expansion to accelerate. So who knows if this could change again... At present our understanding says that the universe expansion-rate will keep accelerating. But left to J. J. Abrams, then the outcome is unknown. These four options represents both what we have theories for and what J. J. might come up with.

## #2241: Brussels Sprouts Mandela Effect

December 13, 2019



I love Brussels Sprouts Mandela Effect; I saw them open  
for Correct Horse Battery Staple.

## Explanation

Brussels sprouts are a leafy vegetable from the cabbage family which were cultivated in Brussels, in what is now Belgium, in the 13th century, giving them their name. Many adults and children dislike Brussels sprouts, perhaps because of their bitterness.

Cueball was one of these people who thought he had a dislike for Brussels sprouts, but after trying them recently he had a change of heart and likes them now. He feels "misled" by the public dislike for Brussels sprouts. Megan chimes in and notes that it is not just him. Farmers started to develop a newer cultivar of Brussels sprouts in the 1990s (as opposed to the 15 years ago referenced in the comic), which taste less bitter than the "original" cultivar of Brussels sprouts that Cueball grew up eating. (A source is provided in the comic as a foot note to Megan's statement. This would be the first of two comics in a row with this type of reference given, the second coming in 2242: Ground vs Air.)

A Mandela Effect is a pseudoscience explanation for a false memory held in common by a substantial number of people. False memories may arise via suggestibility, activation of associated information, the incorporation of misinformation, and source misattribution, and they can be shared, sometimes widely, when one of these triggers happens to many people in a population. But a fringe theory holds that such memories are actually real, in some way related to either reality warping or alternate



universes, leaving many people in a reality that contradicts their memory in minor but specific ways. The name comes from multiple people reporting vivid memories of anti-apartheid leader Nelson Mandela dying in prison in the 1980s, despite Mandela famously becoming President of South Africa and living until 2013.

The characters realizing that brussels sprouts taste good, despite having all of them having distinct memories of the vegetable being unpleasant, is seen as similar to having a widespread false memory.

In the last panel, Ponytail then tricks Cueball into thinking that licorice, another widely disliked food, is good tasting. At this point Megan realizes that this must be a trap. Unlike Brussels sprouts, the taste of licorice has not changed noticeably, so people who hated the taste before are likely to still find it unpleasant.

That Ponytail is up to no good is shown to be true when she additionally claims that silica gel packets are actually edible and taste delicious. This is very false![citation needed] Silica gel packets are typically used as a desiccant, to keep electronics and other moisture sensitive items dry. They are typically marked "Do Not Eat" to warn people that they are not edible. Although not toxic, and even allowed in some form in food, silica gel has a sand-like texture and no flavor or nutritional value, can cause irritation if digested in the raw form, and the packets may contain potentially toxic additives.

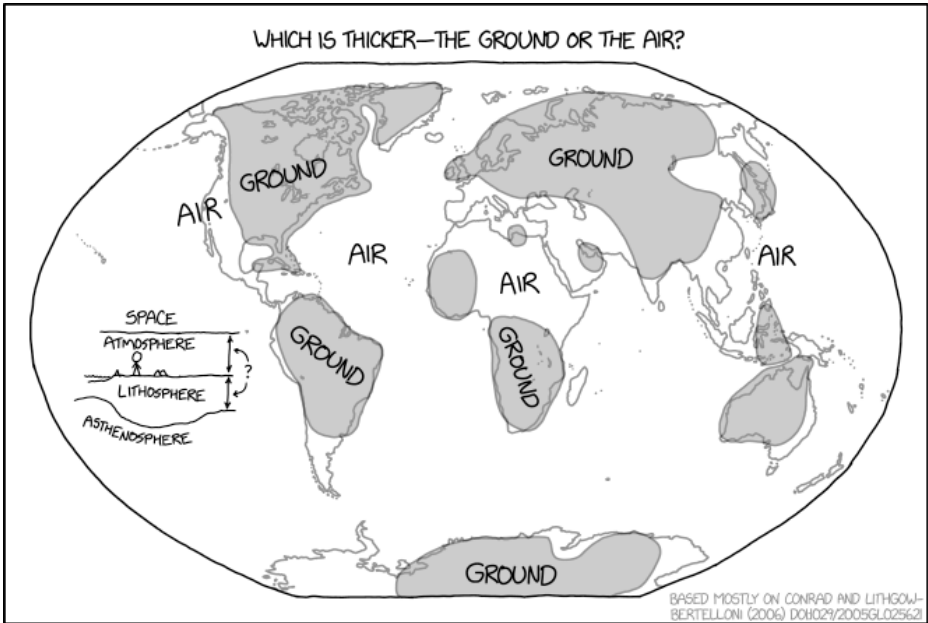
Cueball, having been prepped by both his own experience and Megan's facts, is totally ready to believe Ponytail, even to the extent that he seems to feel cheated by the makers of silica gel packets, who he must now think has written Do Not Eat just to keep that delicious gel for themselves. Hopefully Megan can convince him not to find and eat them. Ponytail is often not nice to Cueball, although in other comics it is more like she talks him down, see Code Quality, not directly trying to harm him.

The title text suggests that "Brussels Sprouts Mandela Effect" is a music band, who once were the opening act for the presumably better known band "Correct Horse Battery Staple". This latter group is a reference to 936: Password Strength. It hints at the "good name for a musical band" trope, which Randall before tried to replace by a dot tumblr dot com trope in 1025: Tumblr. Indirectly, he also suggests that Brussels Sprouts Mandela Effect would be a great long password that is now easy to remember (as long as you remember there is an S at the end of Brussels (at least in English, but not in Dutch, which is one of the official languages of Brussels/Belgium)).

For a comic about awkwardly named bands, see 119: Worst Band Name Ever.

## #2242: Ground vs Air

December 16, 2019



Water is thinner than both, and fire is *\*definitely\** thicker.

## Explanation

This comic depicts a map of the world using the Winkel tripel projection, comparing the thickness of the ground, which is defined as the lithosphere, to the "thickness" (or height) of the air above it, which refers to the atmosphere.

In an inserted figure, Randall defines the thickness using three boundaries. At the top is space, defined by the Kármán line at an altitude of 100 km ( $\approx$  62 mi). (See the Trivia section below for a discussion of this definition of the beginning of space.) Below that is the atmosphere which goes down to the ground, where Cueball is standing, or the water. Beneath the surface is the lithosphere, comprising the Earth's crust along with the rigid upper part of the mantle, and beneath this is the asthenosphere, the partially melted, highly viscous region of the upper mantle just below the lithosphere. The lithosphere is variable in thickness, averaging about 100 km, but the oceanic lithosphere is much thinner than the continental lithosphere (oceanic crust is thinner and denser than continental crust). The diagram also shows oceanic cross-section to the left-hand side and, though the diagram does not make it explicit, presumably the two measurements used are of the atmosphere down from 'space' to the surface of the ground, if dry, or to the surface of the water covering the ground (which is essentially sea level in the oceans, fluctuating slightly with the tides, but covers a broader range for inland water, from the Dead Sea, at 0.4 km below sea level, to Lake

Titicaca, almost 4 km above sea level) and of rock descending from the solid interface down to the asthenosphere, as the sliver of liquid that can intervene between the two spans is referred to as a separate measurement elsewhere.

The map shades in the parts where the thickness of the ground is thicker than the thickness of the air. This almost only occurs directly over continents, and certainly only where the continental crust is located (which can stretch into the near-coast parts of oceans). Oceanic crust is much thinner than continental crust. It is also made of a different material; it is denser. Because it is denser, it floats lower in the liquid asthenosphere, causing it to be below sea level. Some parts of continental crust are also under sea level (the continental shelf). These are the areas on the map that are marked as having thicker ground that appear to be over the ocean (such as Northern Canada, or the Caribbean) - they are actually still continental crust. (There are still some exceptions, such as the Sea of Japan and the Philippines).

Randall has mainly used a work by Conrad and Lithgow-Bertelloni from 2006 to estimate the thickness of the "ground", and he gives the reference to the paper DOI.1029/2005GL025621. Basically, Randall has taken their map and shaded the green and blue areas. It is the second comic in a row with a citation, after the footnote in 2241: Brussels Sprouts Mandela Effect.

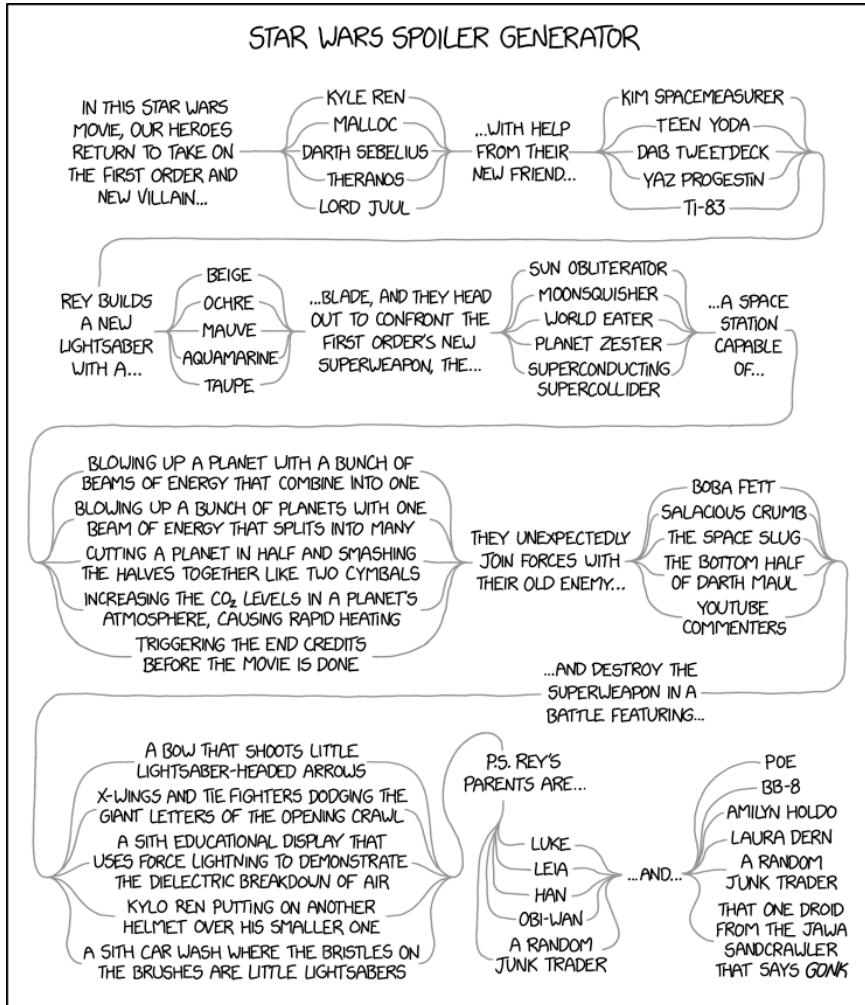
The title text refers to the ancient four classical elements: earth, water, air, fire. The lithosphere, or ground, is earth,

the oceans is water, the atmosphere is air, and fire would thus be the hot, plastic rock of the Earth's mantle, see 913: Core. The mantle is not "on fire", but it is hot enough that it would ignite almost anything on the surface. The water layer on Earth is never more than 11 km deep, even at the deepest part of the ocean, the Mariana Trench, and thus cannot compare to the thickness of the atmosphere or the lithosphere. An expansive definition of "fire" to include the rest of the Earth below the lithosphere puts the fire layer at 6,000 km thick, the radius of the Earth, much thicker than the other layers, hence the and fire is \*definitely\* thicker comment at the end of the title text. Space or vacuum would in the classical element terminology have been called the Aether.

In 977: Map Projections the Winkel-Tripel projection is the fifth projection which is linked to the hipster subculture.

# #2243: Star Wars Spoiler Generator

December 18, 2019



The heroes seem to be gaining the upper hand until Darth Juul manages to flip the switch on the car wash control panel from 'REGULAR' to 'PREMIUM.'

## Explanation

On December 20, 2019 (2 days after the publication of this comic), the final movie of the "Skywalker saga" of Star Wars films, Star Wars: The Rise of Skywalker, was officially released to the US. It received a world premiere in Los Angeles on December 16, so there are lots of spoilers online, and also lots of people who want to avoid spoilers. Randall has created a flowchart that generates "spoilers" to the film, but as he probably has not seen the film (or, if he has, he doesn't actually want to spoil it for us), all of the so-called spoilers are nonsensical.

The formula for each spoiler is as follows: "In this Star Wars movie, our heroes return to take on the First Order and new villain [villain name] with help from their new friend [friend name]. Rey builds a new lightsaber with a [color] blade, and they head out to confront the First Order's new superweapon, the [superweapon name], a space station capable of [evil plan]. They unexpectedly join forces with their old enemy [character] and destroy the superweapon in a battle featuring [strange event]. P.S. Rey's parents are [character] and [character]".

The First Order is the main antagonist group in the Star Wars sequel trilogy series (episodes VII, VIII, and IX). In Star Wars: The Force Awakens, they use a superweapon in their base, Starkiller Base, to destroy the planetary system housing the headquarters of the New Republic, the democratic government which was formed after the Empire's defeat in Return of the Jedi.



"Building a lightsaber" is one of the rites of passage for becoming a Jedi Knight. In the prequel trilogy (episodes I, II, and III), new Jedi build lightsabers as an official part of the journey towards Knighthood, and in the original trilogy (episodes IV, V, and VI), Luke Skywalker builds a lightsaber between *The Empire Strikes Back* and *Return of the Jedi* as part of his training with Yoda. Rey has used the lightsaber that Anakin Skywalker made and used (which Luke also used when he was a new Jedi) for the first two movies of the sequel trilogy, and so it would be thematically appropriate for her to build her own prior to the trilogy's final entry. Most Jedi lightsabers are either blue or green, with a few notable exceptions (e.g., Mace Windu's purple lightsaber, which was chosen because purple is a cool color). Kyber crystals are aligned with the Light Side of the Force, so Sith must overpower and "bleed" their crystals before they will function for them, causing their distinctive red color. Having a lightsaber of a color other than blue, green, or red is often seen in the Star Wars fandom as a sign of being a "Mary Sue", an accusation which has been made of Rey.

Another common plot point in Star Wars media is the construction, use, and destruction of a superweapon. These are inspired by stories and media of World War II, in which militaries rapidly developed novel technologies and weapons (including "wonder-weapons"), while also launching massive operations to find, attack, and destroy critical elements of their enemies' resources and infrastructure, and constructing elaborate defenses for their own. The attack on the Death Star in particular is

inspired by Operation Chastise, the "bouncing bomb" attack on Germany's hydroelectric power plants; Operation Chastise was dramatized in the 1951 book and 1955 film *The Dam Busters*, which was very thoroughly homaged by *A New Hope*. The original trilogy of movies had only two Death Stars, but superweapons quickly became a staple of the Expanded Universe fiction, to the point that one book had Han Solo make fun of the Empire's tendency towards building superweapons, proposing such ridiculous names as "Galaxy Destructor" and "Nostril of Palpatine". Superweapons are also common in superhero stories.

Redemption and making allies of old enemies is also a common plot point in *Star Wars*. Anakin Skywalker fell to the Dark Side and became Darth Vader, but eventually returned to the Light Side to protect his son, and Han Solo was initially a morally ambiguous character who was eventually convinced to join the Rebel Alliance.

Rey, one of the main characters in the sequel trilogy series, is an orphan left behind on the planet Jakku as a child. As Rey is Force-sensitive and adept at using a lightsaber, there is much speculation among *Star Wars* fans as to the identity of her parents. Many major characters in *Star Wars* have unexpected heritages of great portent, most famously Luke, who was very distressed to learn that Darth Vader did not kill his father, as Obi-Wan had told him, but is his father. In *Star Wars: The Last Jedi*, villain Kylo Ren tells Rey that she is the child of "filthy junk traders", but many fans speculate

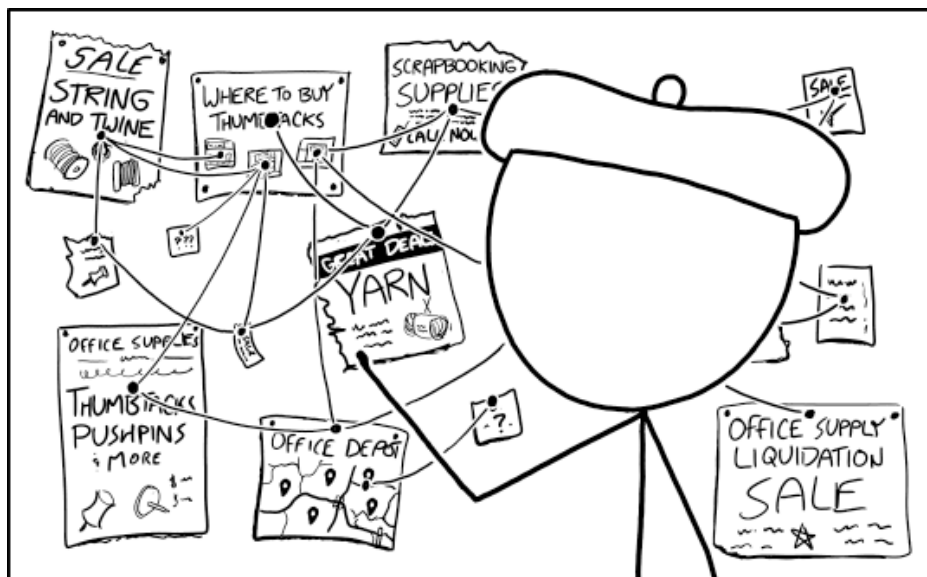
that he was lying to her.

The title text refers to the bottom option of the [strange event in battle] section. Apparently Lord Juul (or Darth Juul) is fighting the heroes in the Sith car wash. It is unclear what "flipping the switch" from Regular to Premium would do, but it seems to be beneficial to Darth Juul. A "premium" car wash usually has more features than a regular car wash, such as more cleaning brushes, waxing the car, cleaning the tires, etc., so perhaps the premium mode activates additional lightsabers.

This is the second false-fact-generating comic, after 1930: Calendar Facts.

## #2244: Thumbtacks And String

December 20, 2019



A tattoo of a tattoo parlor receipt

## Explanation

In many media, crimes and conspiracy theories are solved on bulletin boards. "Leads" are attached to the board using thumbtacks, and the leads are connected to each other using string (specifically twine is mentioned), in order to sort out connections and possibilities. There are many systems for information mapping that show entities as nodes in a graph, with relationships represented by connections between nodes.

Beret Guy, eccentric as always, manipulates this by making just such a setup solely to determine where to buy the thumbtacks and string for use in it. The joke is that the bulletin board is entirely self-referential -- without a need for thumbtacks and string to hold and connect things on the bulletin board, there would be no need for the bulletin board itself, but because of the bulletin board's string and thumbtacks, Beret Guy needs the items advertised on it. An additional minor joke may be that the Office Depot store map near the bottom of the bulletin board has markers that are often called "digital pushpins".

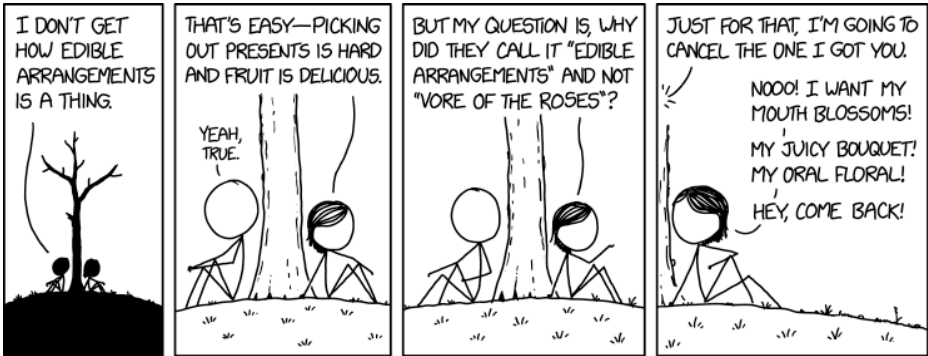
In media, characters (especially conspiracy theorists) tend to obsess over these boards, overanalyzing or staring at every little detail to try and make sense of them -- Beret Guy may be so obsessed with these string boards that he has been driven to obsessing further over the details of making more of these boards.

The title text continues the self-reference theme: The receipt for the tattoo is tattooed to the person who orders the tattoo, which is the receipt for said tattoo of the receipt. This has happened for real in Norway.

The idea of the receipt being the object you buy, has been used in a rug that used to be sold by IKEA.

## #2245: Edible Arrangements

December 23, 2019



Any arrangement is an edible arrangement if you're hungry enough.

## Explanation

This is the first of two Christmas comic released around Christmas of 2019, with 2246: Christmas Presents being the second Christmas comic, released on Christmas Day. It is also the first of two comics in a row about presents, and it is also the last comic released before Christmas Day.

Edible Arrangements is a company that sells fruit, and other edible items that have been cut and arranged to look like flower bouquets. They can be ordered and sent to a given recipient for a variety of purposes. Flower arrangements are typically not eaten, as showy flowers are so economically inefficient to mass produce that modern culture has forgotten they are edible.[citation needed]

In the first panel, Cueball seems to find the concept incongruous, and wonders how it came about. Megan points out the easy answer: picking out a gift for someone can be difficult, but a tasteful meal is always welcome so long as it's something the recipient can eat safely.

Shortly afterwards, Megan uses the same incongruity of eating a floral arrangement to make puns. Vore of the Roses is a play on the War of the Roses, either the English civil war or the 1989 movie of the same name. 'Vore' is a word part referring to eating, as in carnivore (meat eater), herbivore (plant eater), voracious (hungry or eating a lot), etc. It's also used on the internet to refer



to the fetish vorarephilia, in which one gets sexually excited about the idea of eating or being eaten by someone (not in the metaphorical sense of oral sex, but actually consuming someone whole).

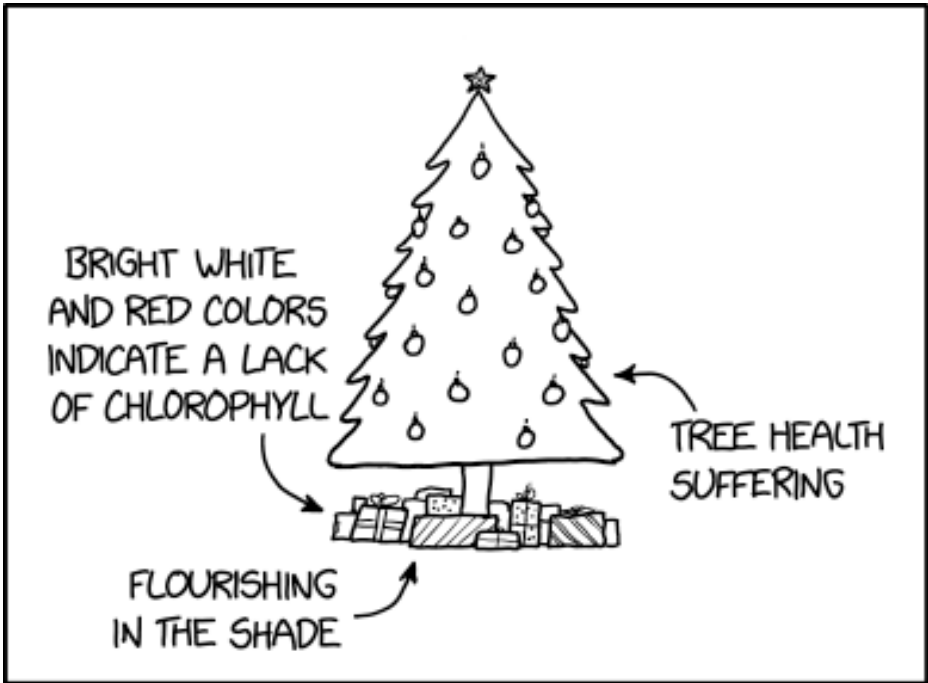
Cueball is probably in pain because of the bad pun (or perhaps because he doesn't like the idea of food items desiring to be eaten) and says he will cancel the edible arrangement that he had bought for Megan. She tries to convince him otherwise by providing alternative names, which are evidently not any more to his liking, since he has left Megan before she's finished with her suggestions.

Mouth Blossoms, Juicy Bouquet, and Oral Floral are all combinations referencing the eating of a floral arrangement. In theory, these combinations could be good names for a band, or possibly a tumblr blog.

The title text also makes reference to the fact that many flowers that are often found in floral arrangements, such as roses, violets, tulips, daisies, lavender and many more, are items that a human can eat. Such flowers are safe to consume but usually unappetizing; Randall makes the point that if a person is sufficiently hungry and thus doesn't care how appetizing their meal is, any floral arrangement can be eaten. Since he doesn't use flower in the title text, he actually says that if you are hungry enough anything can be eaten. The title text may also be an allusion to a Mitch Hedberg joke: "Any book is a children's book if the kid can read!"

## #2246: Christmas Presents

December 25, 2019



THE EVIDENCE IS CLEAR: CHRISTMAS  
PRESENTS ARE PARASITIC PLANTS.

"The parasitism might be mediated by a fungus!" exclaimed  
the biologist who was trying to ruin Christmas again.

## Explanation

This is the second Christmas comic in a row after 2245: Edible Arrangements. It is also the second comic in a row about presents, this one in particular calls them Christmas presents, and this comic was released on Christmas Day.

A Christmas tree cut down from the woods will typically be placed in a living-room soon after being cut down, and left standing there through the holiday season. On Christmas Eve or Christmas Day, or even earlier, presents are typically put beneath the tree under the lower branches. Once the tree is cut down, it will eventually start turning brown and/or losing its needles as it no longer receives any nutrients from its roots.[citation needed]

Based on this observation (on Christmas Day) some biologist (or Randall) concludes that the presents are a type of parasitic plant—that is, a plant that derives some or all of its nutritional requirement from another living plant. Since such a plant can use the sugars produced by the parasitized tree it does not necessarily have to perform photosynthesis by itself (although some parasitic plants such as mistletoe are photosynthetically active). If the parasitic plant is not doing photosynthesis it can live in the shade beneath a tree that it parasitizes as it has no need for light, and since it does not need chlorophyll either, it may not be green (e.g. *Orobanche*).

With presents often being wrapped in bright white and red colored paper, Randall concludes that this indicates a lack of chlorophyll, thus fitting with the idea of a parasitic plant. With the presents being in the shade of the tree and the tree's health suffering, the evidence can only lead to the conclusion that Christmas presents are parasitic plants.

In the title text a biologist says that "The parasitism might be mediated by a fungus!" While many parasitic plants attach themselves directly to the plant they are parasitizing (e.g. mistletoe, a parasitic plant which is often used to symbolize romance at Christmas) this is obviously not the case with the Christmas presents which are not growing out of the Christmas tree - which appears to rule out a parasitic relationship. However, the biologist has an answer for that: Some parasitic plants (such as snow flowers) do not attack the tree directly but instead form a connection to mycorrhizal fungi. These fungi are receiving sugars from the trees and in turn provide it with mineral nutrients. By parasitizing these fungi, the snow flower can steal the sugars of the tree indirectly. One says that the fungus is mediating the parasitism.

Randall dismisses these words as coming from a biologist who is "trying to ruin Christmas again", which could have several meanings. It could be that the biologist really is just trying to ruin Christmas, and is trying to be more successful than in previous years by tying Christmas presents to fungus in people's minds. One might say that the biologist is not a "fun guy" for doing

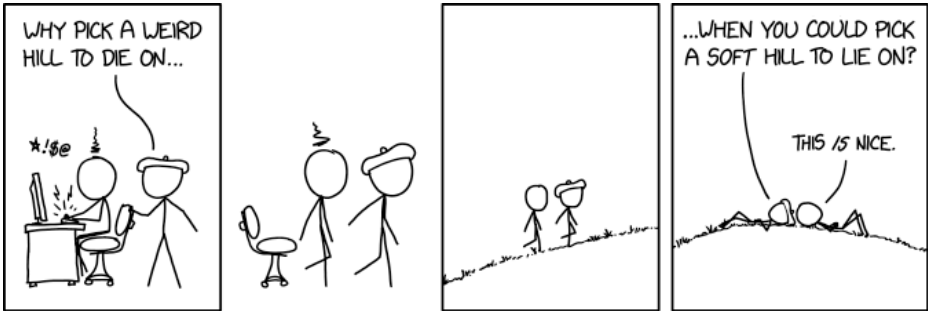
this. [citation needed]

It could instead be the case that the biologist is quite earnest in his belief that Christmas presents are harmful plant parasites and is attempting to spray the presents with a fungicide, which would probably be toxic and potentially contaminate not only the wrapping paper but also the presents inside their boxes.

Finally, it could be that the biologist is right, and Christmas presents are hosts to or otherwise associated with a parasitic fungus (and Randall's dismissal is a sign of his infection). There are some parasitic fungi that hijack the brains of host animals and alter their behavior. The most famous of these is probably *Ophiocordyceps unilateralis*, the so-called "zombie ant fungus", which causes its hosts to perch on a high plant to maximize the distance traveled by the fungus's spores. Ants have in turn developed strategies for detecting and removing infected members from the colony's territory. None of these fungi are known to infect humans, but they did inspire the zombie fungus in *The Last of Us*.

## #2247: Weird Hill

December 27, 2019



I'm compromising by picking a weird hill to lie on.

## Explanation

This comic is a joke about the expression "a (weird) hill to die on", which refers to holding a position as if it has great importance, and being willing to fight for that position, no matter how much opposition you face, or how little benefit is derived. The term comes from the military practice of capturing and holding hills in disputed areas, in order to command the high ground. Because hills tended to be highly disputed, soldiers would frequently die in their defense. Hence picking "a hill to die on" implies that you're choosing a position that you consider to be so important that you'd defend it at the cost of your own life. The term is generally used to point out the pointlessness of defending a rhetorical position with such fervor, particularly if the point is not especially important, and/or the other party is unlikely to change their views.

In this strip, Beret Guy interrupts Cueball, who is apparently arguing with someone who is wrong on the Internet. Pulling him away from the argument, Beret Guy asks why Cueball should pick a weird hill to die on (fight over an opinion online) when he could pick a soft hill to lie on, going out into nature and relaxing. This comic has a similar message to 386: Duty Calls, 1731: Wrong, and 2051: Bad Opinions. The theme is sometimes we either assign too much importance to our opinions, or we expend too much effort trying to persuade others, and it's often wiser to simply let the argument go. Leaving a computer problem to relax in

nature was also mentioned in 1024: Error Code.

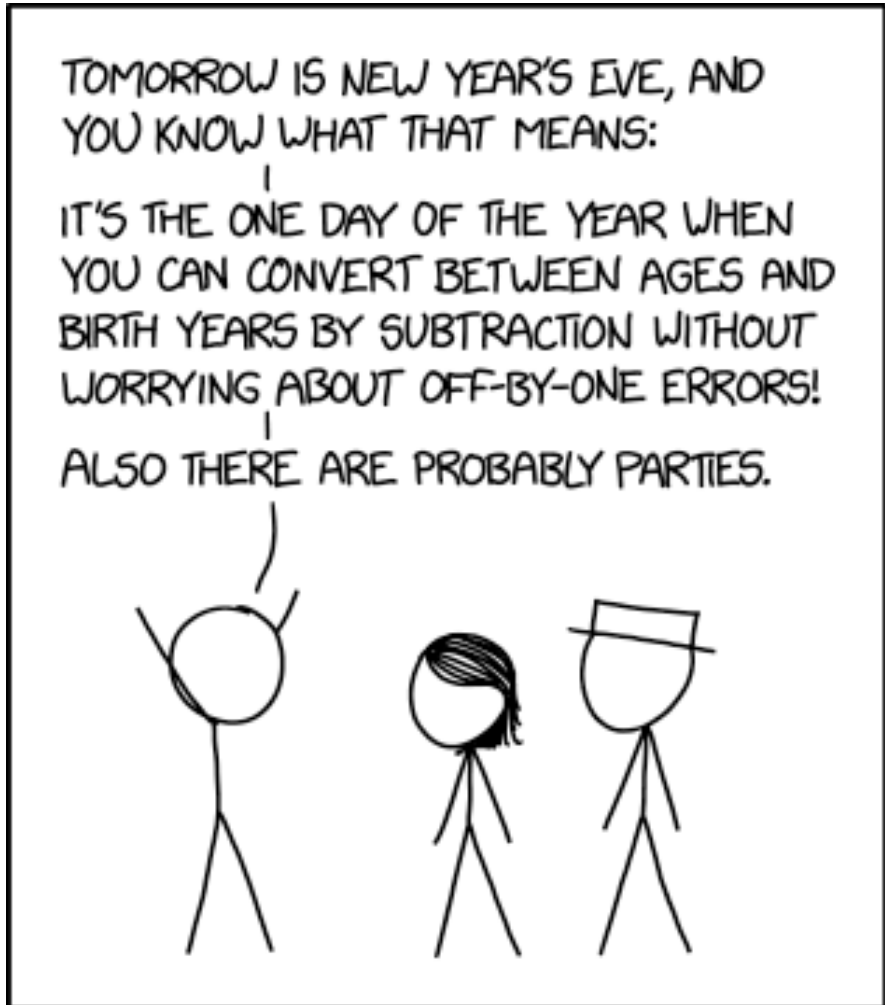
The title text is an absurd juxtaposition: that Cueball will pick a weird hill to lie on. In this case, he may be referring to a physical hill, in which case the meaning of "weird" is unclear due to lack of context.

The phrase "a weird hill to die on" was also featured in 1717: Pyramid Honey. (Normally the expression is just "a hill to die on".)



## #2248: New Year's Eve

*December 30, 2019*



"Off-by-one errors" isn't the easiest theme to build a party around, but I've seen worse.

## Explanation

This was the first of two New Year comics around the 2019-2020 New Year, the second being 2249: I Love the 20s.

An easy way to determine someone's age is to subtract their birth year from the current year. However, if their birthday has not happened yet that year, this calculation will predict them to be a year older than they actually are. By New Year's Eve, everybody's birthday has happened that year (or is happening, but legitimately tallied up), so this error will not occur. Cueball is excited by this, whereas most people would be more excited by the parties that typically occur around New Year's.

"Off-by-one" errors are commonly made in computer programming, especially by novices, when looping over sets of objects. They can also appear in everyday life. If one is given a range of numbers, such as  $\{10, 11, 12, \dots, 99, 100\}$ , a common error is to assume that the number of numbers in the range is the first number minus the last number:  $100 - 10 = 90$ . However, the correct answer is 91 since both endpoints are included in the set. This specific type of "off-by-one" error is called a fencepost error; as-in, a fence with ten fence segments will require eleven fenceposts to support it, but many may erroneously believe that it requires ten fenceposts (one post for each segment).

In the title text, Cueball suggests a New Year's Eve party

with the theme of "off-by-one errors", saying it's challenging to build off of but that he's heard of worse. No information is given as to what such a party theme would entail, nor what could possibly be a worse party theme. (On the other hand, the parties depicted in 51: Malaria and 829: Arsenic-Based Life, based on themes of disease and poison, respectively, look much worse than an "off-by-one errors" party would likely be.)

The idea of off-by-one errors for a New Year's Eve party is inspired by the numerous discussions about the time when the next decade starts, whether 2020 or 2021. 2249: I Love the 20s also treats the subject directly.

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